NAVAL POSTGRADUATE SCHOOL
Monterey, California

OPTIMIZING THE PRIVATIZATION OF MILITARY FAMILY HOUSING

by

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December 1998

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This thesis optimizes the privatization of military housing in the Monterey Bay area. We developed two spreadsheet models of the Monterey Bay Military Housing (MBMH) project to revitalize 2200 military family housing units. We used these models to evaluate several proposed privatization strategies, identify the optimal privatization strategy, develop performance estimates for each strategy, and estimate performance tradeoffs.

We conclude that privatizing military housing in the Monterey Bay area can quickly resolve many housing issues. The optimal privatization strategy is to acquire additional land, build new housing, and sell existing housing land. This strategy replaces the entire housing inventory with new homes in three years. Alternatively, the optimal strategy without selling any land is to replace one third of the existing housing units with new homes and renovate the remainder in nine years.

These models can easily be adapted to support housing privatizations at other Department of Defense installations. The models can verify a project's feasibility and develop financial estimates. They can also assist decision-makers assess the benefits of privatization strategies and estimate tradeoffs between strategies. The model's performance metrics can also be used to evaluate contractor proposals. Most importantly, the models facilitate "what if" analysis throughout the privatization process.

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OPTIMIZING THE PRIVATIZATION OF MILITARY FAMILY HOUSING

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ABSTRACT

This thesis optimizes the privatization of military housing in the Monterey Bay area. We developed two spreadsheet models of the Monterey Bay Military Housing (MBMH) project to revitalize over 2200 military family housing units. We used these models to evaluate several proposed privatization strategies, identify the optimal privatization strategy, develop performance estimates for each strategy, and estimate the performance tradeoffs.

We conclude that the DoD can quickly resolve the housing issues in the Monterey Bay by privatizing the military family housing function. The optimal privatization strategy of acquiring additional land, building new housing, and selling the existing housing land will replace the entire housing inventory in three years. Alternatively, the optimal strategy without selling any land will replace over one third of the existing housing units and renovate the remainder in nine years.

These models can easily be adapted to support housing privatizations at other DoD installations. During site selection they can verify a project's feasibility and develop financial estimates. They can develop detailed privatization strategies and estimate tradeoffs for each project. They can also be used to evaluate and provide performance metrics of contractor proposals. Most importantly they facilitate "what if" analysis throughout the privatization process.

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EXECUTIVE SUMMARY

The military housing in the Monterey Bay area faces several significant challenges. Like most of the Department of Defense (DoD) it has a growing housing shortage, an aging housing inventory, and inadequate funding to support maintenance and renovation requirements. Unfortunately, the Presidio of Monterey (POM) and Naval Postgraduate School (NPS) housing budgets are inadequate to revitalize the current housing or build additional units. To correct these problems the DoD is privatizing all military family housing in the Monterey Bay area. The Monterey Bay Military Housing (MBMH) project's objective is to renovate or replace all existing military housing, and build additional housing to eliminate housing shortages within the next ten years.

Privatizing military family housing in Monterey is a challenging task for several reasons. First, military housing privatization is an immature process that is still being refined. Second, the DoD has never privatized such a large number of housing units. Third, the MBMH project involves a large number of Federal, state and municipal organizations. Fourth, the DoD must consider an unusually wide variety of privatization strategies made possible by the high value of housing land and water rights in the Monterey Bay area. Finally, the project must consider privatization issues unique to the Monterey Bay such as a high proportion of officers and high turnover rates. To date, the POM and NPS do not have sufficient analytical tools to address the MBMH project's complexity and wide range of alternatives.

This thesis developed two spreadsheet models to assist the NPS and POM decision-makers develop detailed privatization strategies for the MBMH project. The two models were used to determine the optimal mix of housing units to build and renovate, develop annual revitalization schedules, and provide initial financial estimates for the project. These models were also used to estimate the time and money tradeoffs within specific privatization strategies. The objective of both models was to maximize command utility based on desired service member-housing assignments.

This analysis indicates that available land is the limiting factor in the MBMH project. The MBMH project must acquire additional land if is to satisfy the future housing requirements while revitalizing existing housing units. Additional land and housing units are required to replace the existing units that are taken off-line for renovation. The optimal sequence of actions is to construct new housing to prevent a shortage, renovate the best existing housing units, and then dispose of the most deteriorated units when they are no longer needed. Any revitalization strategy that does not acquire additional land and construct additional housing will result in a housing shortage or a significant number of unsatisfactory housing assignments.

The models demonstrate that the MBMH project should be a joint (Army – Navy) project because both the Army and Navy bring essential assets to the project. The Army owns significant land and water rights at the Presidio of Monterey Annex. Selling these assets will increase the project's available funding by at least 19%, allowing the project to build all new housing. The NPS's large number of mid-grade officers significantly increases the project's expected average rent (the service members' Basic Housing Allowance) per housing unit and the expected annual revenue. The expected average rent for a joint project is $100 higher per month than in an Army-only project. Also, a joint project produces an annual revenue of approximately $30.7 million versus the $14.6 million for an Army-only project. We assume that the higher rent and annual revenue will enable the project contractor to provide significantly better housing.

The optimal MBMH privatization strategy is to acquire additional land, build new housing units, and then sell most of the POM Annex housing land. This strategy provides the DoD the best housing possible because it replaces all existing housing with new housing units (except for historical units) and constructs new community facilities in less than three years. This strategy provides the best housing because it fully leverages the commercial value of the POM Annex land. In the first year the project incurs $150 million in debt but reduces debt to $87 million by the end of the third year by selling most of the POM Annex land. By the end of the third year all 51 historic units have been renovated and over 2400 new housing units have been constructed. The project pays off

the remaining debt over the next 13 years. During the last 14 years of the 30-year contract the project accumulates a significant surplus.

The optimal strategy that does not sell any land produces 24% less command utility and takes three times as long to resolve the housing issues. Without selling land the best privatization strategy is to acquire additional land, build new housing and renovate much of the existing housing. This strategy can build 900 units in the first year but requires nine years to renovate 1525 existing units. It constructs several new community facilities in the first year but does not construct a guest lodge. This strategy includes a housing shortage in the ninth year, when the majority of existing housing assets are renovated.

Although the MBMH project's maximum debt has little impact on the project's ability to meet the housing requirements it does have a significant impact on the time required to revitalize the entire housing inventory. Allowing the project to borrow up to $150 million will enable the project to complete the revitalization in three years. Greater project debt will not reduce completion time. Mandating a "pay as you go" project that does not carry any debt from year to year delays project completion to nine years.

Because the optimal strategy includes selling land, changes in commercial land value have a significant impact on the MBMH project. In the optimal privatization strategy the revenue from land sales is $191 million, accounting for 18.7 % of the MBMH project's total revenue. Therefore deviation from the estimated value of $500,000 per acre could significantly affect the MBMH project and change the optimal course of action. However, land values above $500,000 per acre do not result in significantly increased command utility.

These models can be used to reduce the uncertainty of family housing privatization at other DoD installations. These models assist decision-makers in developing privatization strategies and revitalization schedules. These models will also enable project planners to explore alternatives, verify feasibility, develop financial estimates, quantify performance and cost tradeoffs, and answer "what if" questions.

I. MILITARY FAMILY HOUSING

Military family housing in Monterey, California is facing several problems common to most Department of Defense (DoD) family housing facilities. First, there is insufficient housing for service members assigned to the Presidio of Monterey (POM), Naval Postgraduate School (NPS) and other military units in the Monterey Bay area. Service members awaiting military housing often cannot afford adequate housing in the Monterey Bay area. The lack of military housing combined with the high cost of Monterey housing creates unnecessary burdens to service members. Second, most of the housing units at the NPS and the POM were constructed between 1958 and 1961, and have received only limited improvements since construction (Dames & Moore, 1996). Decision-makers at the POM and NPS agree that these units will require revitalization (renovate or replace) within the next five years. Third, the military housing budget is not adequate to correct these deficiencies in a timely manner.

One way to resolve these issues may be to privatize military housing in the bay area. Under privatization, a civilian company manages the housing system, renovates or replaces the current housing, and builds additional housing to meet housing requirements. In exchange the company receives the service member's Basic Housing Allowance (BHA). The DoD believes that privatization will correct housing deficiencies in less than ten years, which is considerably faster than possible with a normal military construction program (Bayer, 1996).

Developing a privatization plan for the 2,200 military housing units in the Monterey Bay is a complex task. The decision-makers must consider a large number of alternatives that range from renovating and upgrading the current housing inventory to selling the current property and building all new housing. They must also resolve a host of privatization issues unique to the Monterey Bay. Currently the NPS and POM do not

have sufficiently rigorous analytical tools to evaluate the alternatives or develop a privatization strategy.

A. HISTORY OF MILITARY FAMILY HOUSING

Today the DoD is the United States' second largest housing provider, exceeded only by the Department of Housing and Urban Development (Professional Builder, 1997). The purpose of military family housing is to provide housing for military families where adequate housing is not available in the local communities. The DoD's policy is to rely on the commercial housing market as much as possible. It does this by providing a Basic Housing Allowance (BHA) to service members to obtain commercial housing. Military family housing is only intended to fill a shortage of adequate housing, generally when military posts are in remote or high cost of living areas. (CBO, 1993)

The first military housing construction program was authorized by the Wherry-Spencer Act of 1949. Private companies built and administered over 114,000 family housing units on private land. A second military housing construction program, the Capehart Act of 1960, provided for the construction of over 115,000 housing units on Government land. The DoD took over mortgage payments and operations of the Wherry-Spencer and Capehart housing units soon after the Capehart units were completed. In both housing programs private companies funded the entire project without Government assistance. During the 1960's and 1970's the DoD built over 100,000 additional housing units with military construction funds (Chapman, 1996). (See Figure 1.) By 1993, the DoD was maintaining over 300,000 family housing units at an annual cost in excess of $3 billion (CBO, 1993).

B. CURRENT MILITARY FAMILY HOUSING SETTING

In 1996, the DoD's 387,768 family housing units had an average age of 33 years (Chapman, 1996). The majority of these houses will soon reach, or have already passed,

the end of their economic service life of 35 years. Today, approximately two-thirds of the existing family housing units require major renovations, which would require a significant increase in military housing funding. Under the normal military construction process, these renovations would cost over $20 billion and take over 30 years (GAO, 1998). (See Figure 2.)

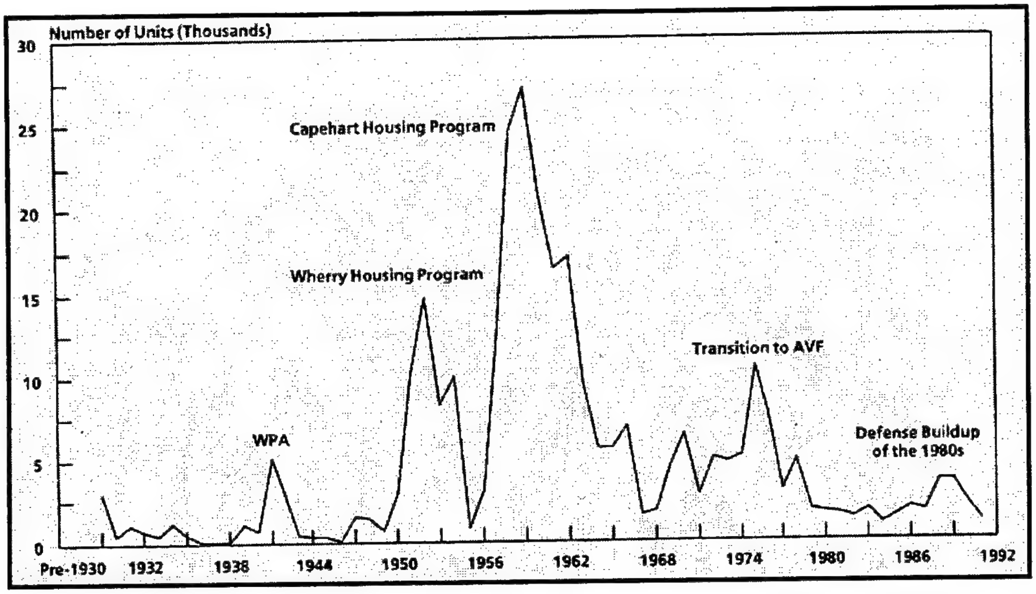

Figure 1. Annual Acquisition of DoD Family Housing Units (CBO, 1993)

Delayed maintenance constitutes a major portion of the need for increased housing funding and is a direct result of the inadequate funding in the past. Military family housing has been inadequately funded since the end of major construction programs in the 1960's. During the 1980's defense build up and the 1990's military drawdown, military housing funding was critically short. Consistently low funding caused a wholesale deterioration of military housing, led to higher than average maintenance costs, and created an $11 billion housing maintenance backlog by 1994. (CBO, 1993)

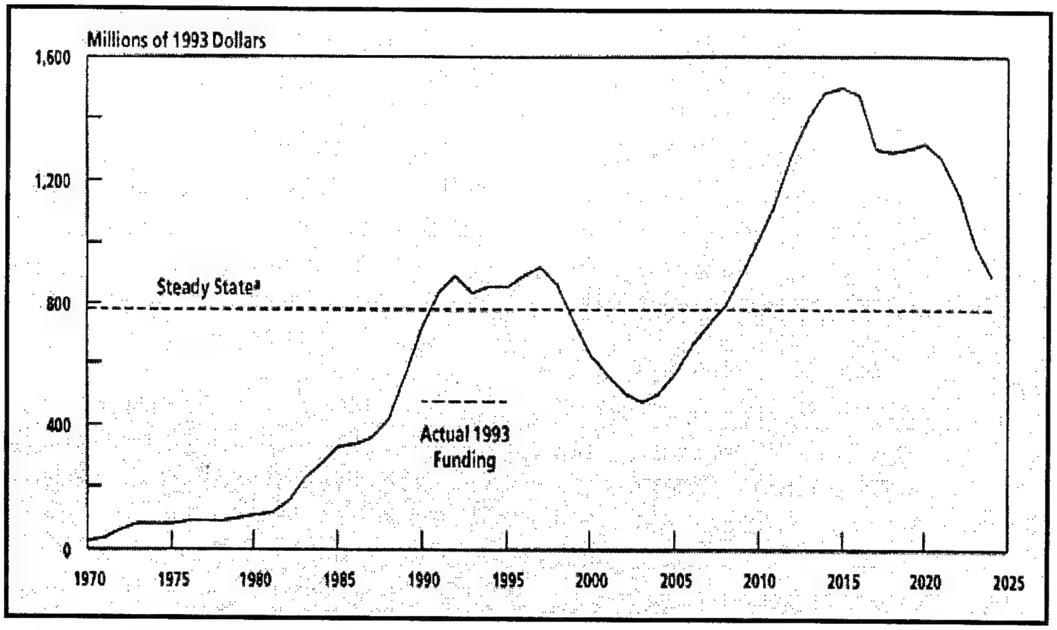

Figure 2. Funding Required to Revitalize DoD Family Housing (CBO, 1993)

Despite these problems, service members prefer military housing; some even view it as an entitlement. This is primarily because the DoD housing allowance covers only 80% of the average housing costs in local communities and service members bear the remaining cost (GAO, 1998). However, those living in military housing forfeit only the housing allowance and do not incur any out-of-pocket expenses. They also do not pay for utilities. Further, many families prefer the sense of community and security that many military housing communities offer. They also value the convenience of living close to military support facilities such as commissaries and exchanges.

The poor condition and unavailability of military housing, exacerbated by 15% of service members living in unsuitable private housing, are adversely affecting service member's morale, job satisfaction, and quality of life (GAO, 1998). The housing problems are also degrading DoD's ability to recruit and retain quality servicemen. Low quality of life, low pay and a lack of quality housing have become soldiers' top reasons for leaving the Army (Twiss, 1996).

In 1997, Secretary of Defense Perry listed housing problems, and other quality of life issues, as one of his highest priorities (Housing Revitalization Support Office, 1997).

The DoD wants to correct its housing deficiencies but lacks the resources to do so. Limits on defense spending, enacted in the 1996 budget agreement, preclude large-scale housing initiatives, while unfunded operations abroad threaten to further reduce housing's funding.

C. SOLUTION: PRIVATIZE MILITARY FAMILY HOUSING

The DoD is privatizing military housing to revitalize it more economically and quicker than possible with traditional military construction programs. The DoD's objective is to revitalize (renovate or replace) all military family housing by the year 2010 through privatization. The Army also intends to eliminate all family housing appropriations (i.e., completely privatize family housing) by the year 2005. (Office of Deputy Chief of Staff for Engineering and Housing, 1998) The DoD estimates that privatization can revitalize all military housing in 10 years for approximately 25% less cost than military construction programs (GAO, 1998). This is much faster and cheaper than normal military construction programs.

Privatization is a "type of outsourcing involving the transfer of Government assets to the private sector in which the Government sheds capability to perform the outsourced function " (Office of Deputy Chief of Staff for Engineering and Housing, 1998). Outsourcing is having a civilian company perform a function previously performed by the Government. In this case the DoD transfers existing military family housing units and functions to private companies who administer and maintain the housing in exchange for the service members' housing allowance. The companies own the housing assets and renovate, replace or build new housing units to meet the DoD's housing requirements. The companies receive a long-term lease for the housing land.

Privatized family housing will be more cost effective because private companies respond to two forces that do not affect Government organizations: market competition and profit motive. First, Government organizations are not as sensitive to customer satisfaction because they do compete for customers like private companies. Second,

private companies are in business to make a profit so they are motivated to be as cost-efficient as possible. The Federal budget system does not incentivize Government organizations to be efficient. These two forces are partially responsible for inefficiencies in DoD housing: the average military housing unit cost 35% more to own and operate than the average civilian rental unit in 1993 (CBO, 1993).

Another advantage of privatizing military housing is that privatization can leverage large amounts of private capital instead of relying solely on Government funding. The DoD expects to "leverage our limited appropriated funds to get a 3 to 1 return on investment" (Johnson, 1997). The Wherry-Spencer and Capehart military housing programs are good examples of how DoD has leveraged private capital in the past. In both programs private companies raised the capital necessary to construct new housing units, enabling the DoD to rapidly expand its family housing inventory (Chapman, 1996).

Congress has recognized the potential advantages of privatizing military housing and granted the DoD new authorities in the 1996 Defense Authorization Act to facilitate housing privatization. It authorized the DoD to guarantee loans and rental occupancy, convey Federal property and facilities to private companies, make differential payments to supplement housing allowances, enter limited partnerships, and request direct loans. Congress also granted waivers allowing the DoD to build military housing units to local standards instead of Federal codes, add new community facilities, and out-lease Federal land and facilities. (Housing Revitalization Support Office, 1996)

Fort Meade is a good example of how the DoD can use these new authorities to improve family housing. This project combines out-leasing 250 acres of unused Federal land to a private company, conveying 250 junior Non-Commissioned Officers (NCO) quarters to the private sector, and outsourcing military family housing administration into one project. The project will replace the existing 2,488 housing units, renovate 112 historic units, and build 303 additional units to reduce the current housing shortage in exchange for the service members' BHA. Initial feedback from private companies is that

they can complete this project in less than ten years. (Office of the Deputy Chief of Staff for Engineering and Housing, 1998)

However, the DoD has made slow progress in privatizing military housing. This is largely because privatization is a new way of doing business. The Federal Government, contractors, and the DoD must develop new and radically different procedures for managing military housing. Additionally, these procedures raise new legal, contracting, and financial issues. Finally, the procedures must be tailored to the assets and requirements of each installation. (GAO, 1998)

D. MONTEREY BAY MILITARY HOUSING PROJECT (MBMH)

The DoD maintains a large presence in the Monterey Bay area. The Presidio of Monterey (POM) is the home of the Defense Language Institute (DLI) which trains the majority of foreign language linguists in the Army, Navy, Air Force, and Marines. The Naval Postgraduate School (NPS) provides graduate degrees to officers from all Services, and is a major DoD research facility. Most of the service members in the Monterey Bay occupy military family housing on the Presidio of Monterey Annex (POM Annex), formerly part of Ft. Ord.

The military housing in the Monterey Bay area faces several significant challenges. Like most of the DoD it has a growing housing shortage, an aging housing inventory, and inadequate funding to maintain these units. Although the DoD has retained military family housing on the POM, POM Annex, and the NPS, an additional 397 family housing units are required (Jack Faucett Associates, 1998). The majority of the 2,200 existing units were built in 1959, with an average unit age of 38 years (Dames & Moore, 1996). (See Table 1.) These aging units have high water, utility, and annual maintenance bills. Additionally, the POM and NPS housing budgets are inadequate to revitalize the existing housing, much less build additional units.

Housing Area	Occupants	# Housing Units	Year Constructed
Stilwell	Officer/NCO	716	1958 / 1959
Fitch	Officer	446	1959 / 1961
Marshall	NCO	353	1961
Hayes	Junior Enlisted	176	1959

Table 1. POM Annex Housing Inventory (Dames & Moore, 1996)

Unless corrected these problems will intensify in the next few years. Without renovation, many units will become unserviceable, further increasing the housing shortage. Maintenance costs for the remaining units will climb with the housing units' age. More importantly, most housing in the Monterey Bay communities will be unaffordable within five years. By the year 2002, only 21% of company grade officers (O-3) and 10% of career enlisted service members (E-6) will be able to afford a private three-bedroom apartment (Jack Faucett Associates, 1998).

The DoD is considering privatizing all military family housing in the Monterey Bay area to correct these problems. This is expected to be a joint Army-Navy program that includes Army housing at the POM and the POM Annex, and Navy housing at the NPS. The objective is to renovate or replace all of the existing military housing, and to build additional housing to eliminate the housing shortage within the next ten years. (Yates, 1998)

Privatizing the MBMH is a challenging task. First, military housing privatization is an immature process that is still being refined. There is no precedent for this project because the DoD has never privatized such a large number of housing units. Although the Army is privatizing family housing at several other large posts no contracts have been awarded. The Army recently withdrew the Fort Carson Request For Proposals (RFP) and is re-examining the housing privatization process (HRSO, 1998).

Secondly, the MBMH privatization will be a complicated task because it is a joint project involving a large number of organizations. The project will have to comply with Army, Navy, DoD and Federal administrative requirements, requiring a high degree of coordination. The project will also require the participation of at least three local

municipal governments. Coordinating the MBMH project with several agencies will be challenging because each agency has its own responsibilities and procedures.

Finally, the MBMH project must consider an unusually wide variety of options made possible by the large amount of highly desirable land and water rights at the POM Annex. They must also resolve a host of privatization issues including unique service member populations and high turnover rates. To date, the POM and NPS do not have sufficient analytical tools to address the MBMH project's complexity and wide range of alternatives.

E. THESIS OBJECTIVES

This thesis developed two spreadsheet models to assist the NPS and POM decision-makers develop detailed privatization strategies for the Monterey Bay Military Housing (MBMH) project. The two models were used to determine the optimal mix of housing units, develop annual revitalization schedules, and provide initial financial estimates for the project. These models were also used to estimate the time and money tradeoffs within specific privatization strategies.

The first model is the Steady State (SS) model. It presents a snapshot of the project once the existing housing inventory has been revitalized and expanded to meet the housing requirements. The snapshot delineates the optimal mix of housing units and land parcels. This model was used to analyze several courses of action under consideration and provide initial findings. These findings helped the MBMH project eliminate several unfeasible courses of action, rank the remaining courses of action, and identify the project's limiting factors. The SS model also identified key issues for analysis in a time-phased model.

The Multiple Period (MP) model is more rigorous than the SS model and addresses complex housing revitalization issues. Because it treats each of the project's first 15 years as an independent event it can provide a detailed revitalization schedule in addition to the optimal housing mix. The MP model was used to identify optimal

privatization strategies, and produce several production possibility curves. The MP model was also developed for use at other DoD installations.

Both of these models can be used throughout the privatization process. They can be used to revise the optimal housing mix, revitalization schedules, and financial estimates as additional data on housing requirements and cost estimates become available. They can also be used to evaluate contractor proposals. More importantly, they enable the decision-makers to explore the full range of privatization alternatives through "what if" analysis.

While this research focused on the MBMH project, the models can be used at other DoD installations. Both models are built on standard DoD housing data and policies common to all installations. Local command housing priorities, NPS and POM housing inventory data, NPS and POM personnel projections, and local cost estimates were used to tailor the models to the MBMH project.

The results indicate that the MBMH project is viable - it can satisfy all housing requirements with the existing housing assets and the service members' projected BHA. The MBMH project can meet the future housing requirements by renovating the existing housing and constructing additional housing over the projects' first ten years, without selling land. However, if it uses new authorities to sell the POM Annex housing areas it will be able to provide new housing for all service members in the Monterey Bay area within a few years. Building new housing units would leave the MBMH project in a stronger position than renovating the existing housing units.

F. THESIS LIMITATIONS

We used current DoD housing assignment policies, which are based on service member's rank and number of dependents. For example, career enlisted service members cannot be assigned to company grade officer housing. This thesis does not evaluate alternative housing policies such as establishing a housing market within DoD. Several

are discussed in the 1993 Congressional Budget Office report "Military Family Housing in the United States."

Another limitation is that the MBMH will have to slightly modify the optimal strategies identified by these models before implementation. This is because the strategies only indicate how many houses of each type to renovate or demolish, not which particular house to renovate or demolish. Likewise they indicate how many acres of each plot of land to sell or acquire, but not which portion. The models also do not attempt to preserve a contiguous military housing development near the military community facilities on the POM Annex. The MBMH project may have to modify the optimal privatization strategies to military housing interspersed among local community housing. Including a contiguous planning constraint in the models would require additional decision variables resulting in unacceptably long solution times.

Bachelor's quarters and barracks are not considered in the MBMH project analysis because the DoD must fund family and bachelor housing separately (GAO, 1998). However, both models can include the housing requirements, current assets and assignments for bachelors' quarters and enlisted barracks.

We give a detailed explanation of specific SS and MP model assumptions in sections III.A and IV.A respectively.

G. RESEARCH QUESTIONS

The primary research question is: What is the optimal privatization strategy for the MBMH project? More specifically:

- What type of housing and how many units should be constructed, renovated or demolished?
- When should these units be constructed, renovated, or demolished?
- Which plots of land should be bought or sold?

- When should these plots of land be bought or sold?
- Which community facilities should be retained, demolished or constructed?
- When should these community facilities be demolished or constructed?
- What are the limiting factors in the MBMH project?

H. LITERATURE REVIEW

Although little research has been done on revitalizing military housing some work has been done regarding the optimization of existing housing assets. An example is the Housing Analysis System (HANS) developed by Guisseppi A. Forgionne and Yehuda S. Frager. The primary objective of the HANS is to automate the preparation of the Segmented Housing Market Analysis (SMHA) report (Forgionne, 1991). They use an interrelated set of over 500 decision heuristics to develop specific housing actions to minimize the construction required to meet housing requirements (Forgionne and Frager, 1998).

The SMHA indicates the optimal housing unit apportionment, cross-leveling, and redesignation. Apportionment involves using unaccompanied housing units to meet family housing requirements. Cross-leveling is assigning service members to housing with more bedrooms than desired to reduce housing shortages. Redesignation uses surpluses in lower-grade categories to meet housing requirements in a higher-grade group by redesignating the intended service member group. The HANS also documents the real housing shortages by grade after all remediation actions.

The HANS significantly reduced the time and effort required to produce the SMHA report, which yielded significant savings. The system also reduced the new housing construction requirements by optimizing the existing assets and improving the private housing availability estimate. (Forgionne, 1991)

Like the HANS, the SS and MP models use surplus housing assets in one category to meet shortages in other categories and identify net housing shortages. However, the SS

and MP models use a command housing utility function to optimize the apportionment, cross-leveling, and redesignation actions instead of relying on a set of interrelated decision heuristics. Optimizing the command utility should provide the best possible use of each installation's housing assets, instead of merely identifying a feasible solution.

The SS and MP models also address several housing issues not included in the HANS. First the SS and MP models schedule the revitalization of existing housing inventory by delineating when housing units should be renovated or replaced. Second, these models analyze the current opportunities to convey Federal land to the public. The resultant privatization strategies indicate when to sell specific parcels of land. Finally, these models provide detailed financial estimates for the implementation of each housing strategy.

A significant difference between this research and the HANS is that the HANS uses an econometric model to estimate the private housing units captured by service members while the SS and MP models do not consider the impact of service members on the private housing market. Rather the SS and MP models assume that the entire housing requirement must be met by military housing because private housing in the Monterey Bay will become prohibitively expensive.

II. THE MBMH PRIVATIZATION INPUTS

The SS and MP models produce a privatization strategy given the MBMH project's inputs. We identified the project's inputs through extensive discussions with local housing officials. The MBMH privatization models require three major inputs: housing requirements, command objectives, and available resources. (See Figure 3.) Each of these inputs has unusual characteristics that make the MBMH program a unique privatization case.

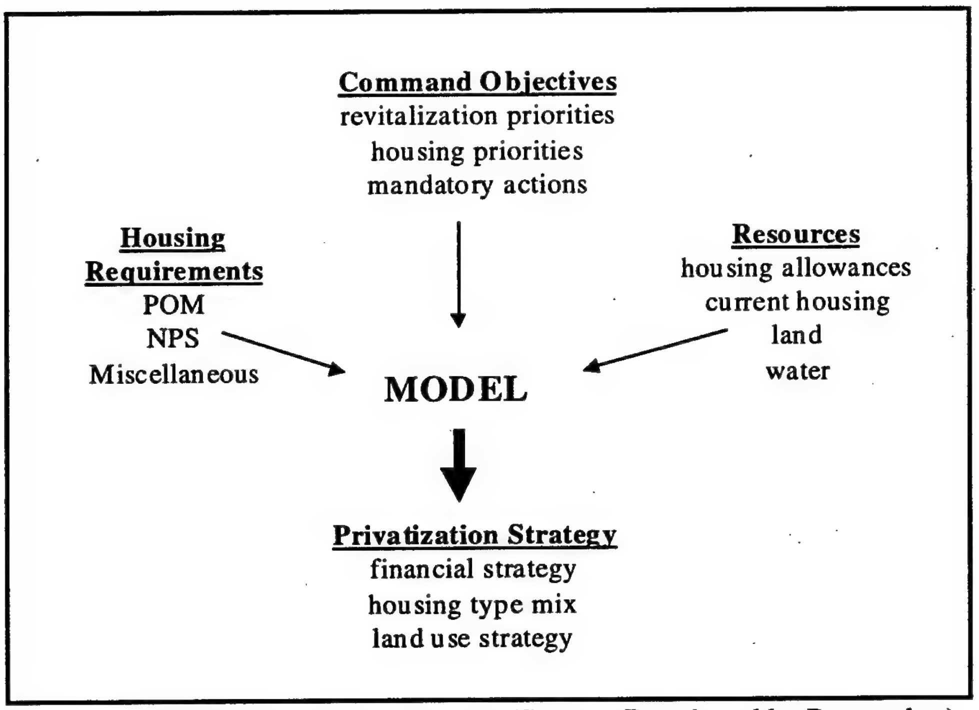

Figure 3. MBMH Privatization Inputs (Source: Developed by Researcher)

A. HOUSING REQUIREMENTS

We assume the MBMH project will include all military personnel stationed in the Monterey Bay area. All service members with dependents stationed within 50 miles of

the POM Annex, the POM or the NPS are authorized military family housing. This research does not differentiate service members by duty station or branch of service.

1. MBMH Service Member Groups

The military housing requirements for the MBMH project differ from those at most DoD installations because its service member population is a composition of three distinct groups. These are the POM, the NPS, and a small group of DoD organizations in the Monterey Bay area. Each of these groups has unique characteristics that define the project's service member population.

Most service members stationed at the POM are Defense Language Institute (DLI) students from all Military Services. The POM and DLI permanent staffs constitute only a small portion of service members at the POM. Most service members at the POM are enlisted DLI students, and many are in Initial Entry Training (IET). The DLI has a high personnel turnover rate because many language courses last less than a year. However, the monthly personnel turnover is fairly regular because the language courses start and end at different times (Defense Language Institute, 1997).

The Naval Postgraduate School is almost entirely mid-grade officers (O3 to O5) from all Military Services. It also has a small permanent staff with a small number of enlisted service members. The NPS has a lower personnel turnover rate than the POM because the vast majority of NPS students stay two years. Unlike the POM however, the monthly turnover at the NPS is cyclical because nearly all students arrive and depart at the end of an academic quarter. International officers at NPS are not included in the future housing requirements because they are only authorized military housing on a space available basis.

The third group includes service members that are assigned to several independent DoD units in the Monterey Bay area. These units include the California Medical Detachment at the POM Annex, a Coast Guard ship based in Monterey, and an Army ROTC detachment. This group has a balanced mix of ranks and Services. It has the lowest turnover rate of the three groups because most of these service members stay three years. Due to the small group size the monthly turnover can vary widely.

Compared with other DoD installations, the MBMH project has a high turnover rate and a high turnover variance from month to month. It has a large number of junior and career enlisted service members that arrive and depart at a fairly even rate throughout the year. It also has a large number of mid-grade officers who arrive and depart in large groups four times a year. This heterogeneous mix of service members from all Military Services is atypical of most DoD installations.

2. Calculating the Monterey Bay Housing Requirements

We based the Monterey Bay housing requirements on the current service member population, the expected population change, and the local commands' desired housing level. The current service member population is the baseline, which modified by the expected change becomes the projected population. The projected service member population is multiplied by the commands' minimum and maximum housing levels to define the minimum and maximum housing requirements.

Housing assignments are based on the service member's rank (E1 to 08) and number of dependents (0 to 4 or more). It was not feasible to model all 110 rank-dependent combinations separately. Instead, the ranks were consolidated into six categories commonly used in military housing. IET students at the DLI were put into a separate category because the POM houses IET students separately from permanent party junior enlisted service members. The housing categories are shown in Table 2.

Category	Grades
Senior Officer (SO)	O6 to O8
Field Grade Officer (FG)	O4 to O5, and WO3 to WO5
Company Grade Officer (CG)	O1 to O3, and WO1 to WO2
Senior Enlisted (SE)	E7 to E9
Career Enlisted (CE)	E5 to E6
Junior Enlisted (JE)	E1 to E4
Initial Entry Training (IET)	E1 to E4

Table 2. MBMH Housing Categories (Source: Researcher)

The current service member population was difficult to measure because no single organization had complete data on the entire population. The POM and NPS personnel

systems could sum the assigned service members, but could not report the number of dependents. The Defense Manpower Data Center (DMDC) could report the number of servicemen and dependents for each group, but did not include the Army, Air Force, and Coast Guard officers at the NPS because they are not assigned to the NPS. DMDC also reported the Marine officers at the NPS in the POM group because they are assigned to the Marine detachment at DLI. The DLI academic records office and the NPS registrar's office did not include the permanent party service members at each post. The joint housing office could report the rank and number of dependents for those in military housing but did not have the data for service members living off-post.

The current service member population was defined by adjusting the March 1998 DMDC data. The Marine officers identified as students at the NPS were subtracted from the POM group and added to the NPS group. The Army, Air Force and Coast Guard officers identified by the NPS registrar were added to the NPS group. These changes could be made without losing accuracy because the NPS registrar's data included the service member's rank and number of dependents. Data from the DLI academic records office was used to separate the POM's junior enlisted group, as reported by the DMDC, into IET and junior enlisted categories.

The March 1998 DMDC personnel data, consolidated into seven housing categories, defined the baseline for all three service member groups. (See Table 3.) We assume that the distributions for service member rank and number of dependents do not change. Therefore, the projected population for each group is defined as the product of the group's current population times its expected change. The MBMH total projected population is the sum of the projected population over all groups. This estimation method allows the projected size of any service member group to change independently of the other groups.

	DLI				NPS				Independent Units			
# dependents	1	2	3	4	1	2	3	4	1	2	3	4
Snr Officer	3.0	2.0	2.0	1.0	2.4	5.4	2.7	5.4	1.0	1.0	1.0	0.0
FG Officer	7.6	8.9	30.1	18.3	89.7	97.1	150.7	69.9	4.0	5.0	6.0	5.0
CG Officer	24.5	36.2	47.2	29.7	241.4	174.0	131.5	67.1	4.0	5.0	3.0	2.0
Snr Enlisted	21.2	27.3	31.3	23.2	4.1	2.7	16.2	8.1	8.0	7.0	10.0	13.0
Career Enlisted	109.1	86.8	69.7	56.6	25.7	23.0	35.1	25.7	26.0	9.0	15.0	9.0
Jnr Enlisted	148.4	63.1	25.1	7.3	10.8	10.8	2.7	0.0	17.0	7.0	0.0	3.0
IET	226.3	90.4	34.5	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total 1236.6				Total 1202.2				Total 161.0			

Table 3. MBMH Baseline Populations (Researcher)

The MBMH project's minimum and maximum housing requirements are defined as a percentage of the total housing requirement for each combination of service member group and number of dependents. (See Table 4.) The minimum and maximum percent housed is based on the local commands' priority for housing that service member group. The minimum was set at 90% for all service member groups, because the DoD's objective is to satisfy 90% of the housing requirement. The DoD does not attempt to provide housing for 100% of the housing requirement because both service members in dual-military couples are assigned to the same housing unit and a small portion of service members will prefer to live off-post. However, the MBMH maximum housing level is higher for junior enlisted, IET students, and company grade service members. This is because the local commands want to provide more housing for service member groups that can least afford adequate housing in the local communities.

We assume that at only 10% of the senior officers, field grade officers, senior enlisted and career enlisted service members will prefer to live in privately owned housing. We also assume that 95% of company grade officers, junior enlisted, and initial entry training service members will prefer to live in military housing. This is a reasonable assumption because little suitable private housing will be available given the Monterey Bay's high cost of living and expected increases. This implies that less than five percent of the projected population will choose to live off-post or are dual-military couples. (Dual-military couples do not receive two housing units.) In March 1993 dual-

military couples constituted only 2.6% of the service members stationed in the Monterey Bay area (Defense Manpower Data Center, 1988).

	Minimum Housing Level				Maximum Housing Level			
# dependents	1	2	3	4	1	2	3	4
Senior Officer	90%	90%	90%	90%	90%	90%	90%	90%
Field Grade Officer	90%	90%	90%	90%	90%	90%	90%	90%
Company Grade Officer	90%	90%	90%	90%	95%	95%	95%	95%
Senior Enlisted	90%	90%	90%	90%	90%	90%	90%	90%
Career Enlisted	90%	90%	90%	90%	90%	90%	90%	90%
Junior Enlisted	90%	90%	90%	90%	95%	95%	95%	95%
Initial Entry	90%	90%	90%	90%	95%	95%	95%	95%

Table 4. MBMH Minimum and Maximum Housing Levels (Researcher)

The future MBMH housing requirements for each of the 28 service member group-number of dependent combinations are defined by a minimum and maximum requirement. (See Table 5.) The minimum and maximum requirements are the products of the baseline populations and the local commands' minimum and maximum housing levels, respectively.

	Minimum				Maximum			
# dependents	1	2	3	4	1	2	3	4
Senior Officer	5.8	7.8	5.2	6.0	5.8	7.8	5.2	6.0
Field Grade Officer	94.4	103.4	173.5	86.4	94.4	103.4	173.5	86.4
Company Grade Officer	251.6	199.9	168.3	91.3	265.6	211.1	177.6	96.4
Senior Enlisted	30.1	33.4	52.3	40.2	30.1	33.4	52.3	40.2
Career Enlisted	145.6	107.7	109.1	83.1	145.6	107.7	109.1	83.1
Junior Enlisted	159.0	73.2	25.1	9.3	167.8	77.3	26.5	9.8
Initial Entry	203.7	81.4	31.1	5.2	215.0	85.9	32.8	5.5
		Total 2383.1					Total 2455.3	

Table 5. Future MBMH Housing Requirements (Researcher)

B. COMMAND OBJECTIVES

The second privatization input is the commands' objectives. These include the commands' revitalization priorities, housing priorities for service member categories, and mandatory actions. The commands may prefer to address all housing issues immediately

or may prefer to incrementally address each housing issue as funding becomes available. The commands also may want to provide additional housing for a specific category of service members. Finally, the commands may deem some actions mandatory, such as constructing a new Child Development Center if the existing facility is sold or demolished.

Command objectives for the MBMH project are based on input from the POM and NPS commanders. The MBMH's primary objective is to resolve the housing issues as quickly as possible. In addition, the POM commander wants to make additional housing available to junior enlisted service members because they are least able to afford suitable housing in the local market. This objective is implemented by increasing the maximum housing levels used to calculate the MBMH housing requirements. (See Table 4.)

In some cases the local command may dictate certain aspects of the privatization. For instance, the command may dictate that the revitalization be complete in five years or not exceed a specific debt limit. These requirements partially define the privatization strategy.

C. RESOURCES

The third privatization input is the project's resources. We assume that the MBMH project will be a joint Army and Navy project that will include all military family housing in the Monterey Bay area. The principal resource available to the MBMH project is the service members' BHA. This is the potential rent for military housing. At many installations the service members' BHA may be the only significant privatization resource. We assume that the MBMH project will not receive Federal Government funding.

The second most important MBMH resource is the land at the POM Annex. Land on the Monterey Peninsula is expensive, and the POM Annex occupies some of the most desirable land available. The POM Annex housing area has a high commercial value

because it has an excellent view of the bay, surrounds two golf courses, is easily accessible, and has a large water allotment. (See Figure 4.) Selling large parcels of land could raise hundreds of millions of dollars. We assume that the MBMH project will retain the proceeds from all land sales.

We assume that all military housing land at the POM Annex, except the Post Exchange (PX) and commissary, can be sold in whole or in part. This assumption allows the MBMH project to take advantage of its unique assets. We assume that none of the NPS or POM housing areas can be sold. Parcels at the POM Annex that may be sold include: Fitch Park, Marshall Park, Stilwell Park, Hayes Park and the PX and Commissary area. Parcels that may be acquired include: Seaside 3, and Monterey County 9 and 10. (See Figure 4.)

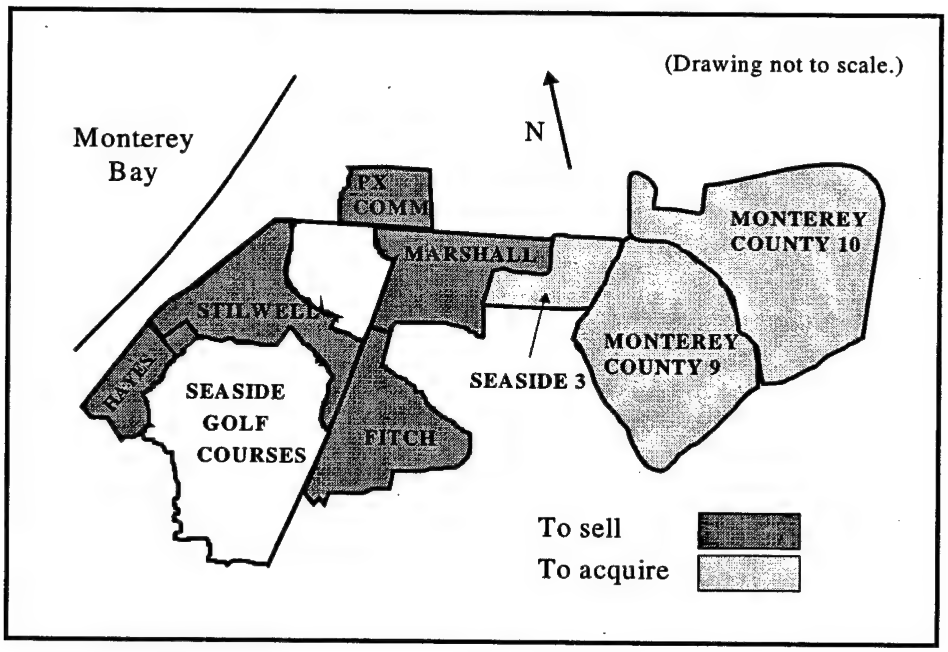

Figure 4. POM Annex Land Parcels (Researcher)

A third resource is the existing housing assets. We assume that all of the housing resources at the POM, the POM Annex, and the NPS will be included in the MBMH project. They represent a large capital investment if they can be renovated cost

effectively. If not, they must be used until they can be replaced. After replacement they could be demolished to make room for other structures or sold with the land they occupy. Many of these units currently require a complete renovation to meet today's housing standards.

The DoD classifies military housing units by the number of bedrooms and the intended occupant's rank category. The housing types range from junior enlisted two-bedroom units to senior officer four-bedroom units. The MBMH project's housing inventory used in this research includes all the POM, POM Annex, and NPS housing units available after the current housing programs are completed.

To facilitate resource planning we classify new housing units by construction type and number of bedrooms. Resource requirements are based on industry utility, land and water usage factors for each construction type. New housing units range from two-bedroom apartments to four-bedroom houses.

We assume that all housing units in a particular category (junior enlisted, senior officer, etc.) are the same type of construction because neither the SS or MP model tracks individual housing units. In reality some of the housing units in some categories are significantly different. For instance the company grade housing includes townhomes, duplexes, and single-family houses. To reflect this mix of housing construction types within a housing category both models use weighted averages to calculate the resource requirements of each housing category. For example, the number of acres required for each company grade housing unit is a weighted average of all of the company grade housing inventory. Specifically, the number of acres required for a company grade housing unit equals the total acres required for each construction type multiplied by the number of units of that type, divided by the total number of company grade housing units.

The last significant resource is the POM's water allotment. Water is an extremely valuable asset on the Monterey Peninsula. Frequently water, not cost, is the limiting factor in commercial developments. The POM and POM Annex are currently allotted 1,410 acre-feet of water per year (Yates, 1998). All POM Annex land that is sold will include a portion of the POM's water allotment.

Water usage rates were adapted from industry estimates (Clark, 1990). Industry estimates for comparable structures and occupancy were used for the housing and community facilities at the POM Annex. We reduced the industry estimates by 15% because they were produced in 1990 and all new or renovated structures will have water conserving equipment (Yates, 1998). We included enough water with all land sold to support a luxury home development.

D. PRIVATIZATION STRATEGY

The output from the MBMH models is a privatization strategy that maximizes the command utility while reconciling the housing requirements, command objectives, and resources. These strategies start in 2001, allowing a year for the MBMH project to begin construction. In accordance with the DoD's objective to revitalize all military housing by the year 2010, we assume that all of the existing housing must be renovated or replaced by the end of the 10^{th} project year. In our analysis no housing, land, or community facility actions are allowed after the tenth year.

Each strategy identifies the optimal annual MBMH project actions. For each year the strategy identifies what fraction of each parcel of land to sell or buy, the number and type of houses to build, renovate, or demolish, and the housing assignments to meet the housing requirements. The privatization strategies also provide a financial plan that estimates the project's annual revenue, expenses, and capital requirements for each year. Assuming that the privatization contract is for 30 years, the project is completed in 2030.

When the privatization strategy is partially predetermined by command inputs the model's output is the optimal strategy given those inputs. The model identifies the other strategy elements that will yield the highest command utility and produces a complete privatization strategy.

III. THE STEADY STATE MODEL

The Steady State (SS) model was used to evaluate several privatization strategies identified by the local commands, including several different NPS participation levels. The model identified the data inputs that had the most impact on the project and provided the first detailed estimates of the project's housing requirements, potential revenue, land requirements, and expenses for each privatization strategy.

A. STEADY STATE MODEL ASSUMPTIONS

The SS model is based on the assumption that the MBMH project will reache equilibrium in ten years. At that point all housing and land actions are completed and housing assignments do not change. Only the project's annual balance changes after equilibrium.

The model identifies the optimal housing and land mix at equilibrium at a single point in time. Therefore, the decision variables represent the sum of all actions taken during the first ten years. We assume that all housing actions are evenly distributed over a number of years. All existing units are renovated or demolished, and ten percent of these are completed in each of the first 10 years. Twenty percent of the total new housing units are constructed in each of the first five years. We assume that none of the existing housing units are abandoned, and that no units are empty at equilibrium.

We assume all land is sold as is, with all existing structures and improvements. This eliminates demolition costs for housing units on land that is sold. We also assume that all land acquired will include all necessary improvements such as roads and sewers. These improvements are not included in housing construction cost estimates.

In the SS model all existing community facilities are retained and no new community facilities are constructed. Community facilities are self-supporting and do not

incur operating costs such as utilities, water or maintenance costs. This allows the SS model to focus on the housing construction, renovation and demolition decisions.

The SS model assumes that all renovated and new housing units will always be occupied. This assumption excludes a maintenance period between occupants which averages less than 4% of a housing unit's life (Washington, 98). Because this "downtime" is excluded the SS model slightly overestimates the revenue and utility of each housing unit.

The SS model also assumes that when there is a housing shortage the lowest ranking service member is assigned housing first. This prioritizes housing for the lower ranking service members in accordance with the local command priorities. This assumption maximizes the revenue lost due to an inadequate number of housing units.

B. DATA

The SS model includes the MBMH project data discussed in Chapter 2, with some additions. The amount of land required for each housing unit was based on estimates from the Army's housing privatization office, Capital Venture's Incorporated (CVI). These estimates were slightly modified to match the actual land use at the POM Annex. (See Table 6.)

	Number of units per acre	
	CVI	MBMH
Senior Officer units	4 – 6	2
Single Family units	4 – 6	4
Duplex units	4 – 6	6
Townhouses	6 – 12	10
Apartments	10 – 18	14

Table 6. Housing Units per Acre Planning Factors (Researcher)

However, applying the land usage rates to the POM Annex initial housing inventory does not account for all land used at the POM Annex. Analysis of the POM

Annex reveals that the land usage rates do not include the public infrastructure, such as major roads and curving residential streets, which occupy much of the POM Annex land. The SS model includes an infrastructure land use factor, based on existing land use ratios, to estimate infrastructure land requirements. Because these factors are rough estimates they are a source of uncertainty.

We assumed that the POM Annex land would have a much higher commercial value than the Monterey County and Seaside land because of its excellent location. Lacking current appraisals, we estimated that the Monterey County and Seaside parcels of land could be purchased for $80,000 per acre. We also estimated that the POM Annex land would sell for $120,000 to $280,000 per acre based on each parcel's view of the bay and proximity to the golf course.

The SS model assumes that funding is a limiting constraint: the MBMH project will not receive Federal funding and must break even by the end of year 30. We expected the MBMH project to incur a large debt to quickly revitalize the existing housing inventory. The revenue from the remaining years is used to pay off the debt, including an annual interest charge. No interest is earned on project surplus in the SS model.

Through a joint agreement between the Army and the Navy the NPS has assignment rights to 600 housing units at the POM Annex. The NPS is currently using approximately 450 housing units. However, the NPS has not finalized its housing requirements or housing strategy. The NPS participation in the SS model varies with each privatization strategy causing the housing requirements to vary with each privatization strategy. The NPS may choose to use none, 600 or 1250 MBMH project housing units. This thesis will assist the POM and NPS determine requirements and develop a joint housing strategy.

The SS model determines the optimal number of housing units to renovate, demolish or construct. However, it does not indicate which specific unit to demolish or renovate because it does not individually track each of the 2,100 housing units in the inventory. Doing so would require a much larger model, and result in unreasonably long optimization times. It would also require a detailed assessment of the current condition

of each unit in the housing inventory. Likewise the model does not indicate which fraction of a parcel of land to sell. It merely ensures that sufficient land is available for all requirements. The MBMH project planners will have to make land disposition decisions in concert with the privatization contractor.

The SS model uses real numbers instead of integers for all decision variables. These include the number of houses to construct or renovate of each type and the number of service members to assign to each housing type. We use real numbers because integers would significantly increase solution times. Using integers in an incomplete version of the Multiple Period model increased solutions times fivefold. Because the MBMH project cannot construct a fraction of a housing unit or assign a fraction of a service member to housing MBMH planners must round the model's recommendations before implementation.

Annual inflation in the SS model is zero so that all financial data remain constant throughout the project. This includes the service members' BHA and cost estimates. We also assume that market value of the POM Annex land will not change until after the project has concluded all land actions.

We set the contractor's profit at 17% of the work performed in each year. In the DoD such "cost plus percent of cost" contracts are prohibited because a contractor can maximize his profits by running costs as high as possible. However, this estimation method is acceptable in the MBMH models because they maximize the command utility not contractor profit.

We also estimated that the contractor's annual operating costs will be 20% of the total annual revenue from service members' BHA. Operating expenses for commercial rental units average about 40% of the gross rent (CBO, 1993, p. 22). However, that expense includes advertising cost and property taxes that will not apply to privatized military housing. Also, privatized housing should have lower operating costs because the large number of co-located and similar units will encourage economies of scale.

The SS model treats the project's financier and contractor as two independent actors to simplify financial calculations. In this arrangement the contractor provides the

necessary operating capital and is paid at the end of each year. The MBMH project maintains an unlimited line of credit from a commercial financial institution to cover annual deficits. The project is charged 8% interest on the annual balance. Although this method ignores the potential advantages of contractor financing, it provides a good baseline for analyzing the MBMH project.

Construction cost estimates are based on Monterey County Housing Authority data. Based on the large amount of construction we included a 5% economy of scale reduction (Yates, 1998). Renovation costs are based on the average cost of repairs required for POM Annex housing units in 1996 (See Dames & Moore, 1996). These cost estimates directly affect a significant portion of the project's expenses, and are a source of uncertainty in the results.

The SS model uses the projected average utility cost for housing units in the Monterey Bay area in the year 2002 (See Faucett, 1998). Based on a CBO study, the SS model also assumes an annual maintenance cost of $3,000 per housing unit regardless of size. This includes all unscheduled plumbing, electrical, and appliance service calls as well as scheduled maintenance between occupants. In 1993 approximately half of the DoD's average annual Operations and Maintenance cost of $6,200 per housing unit was attributable to maintenance (CBO, 1993, p 16 & 23).

C. COMMAND UTILITY

The objective of the SS model is to maximize the local commands' military housing utility. The commands maximize their utility by assigning each service member to the appropriate size and type of housing based on the service member's rank and number of dependents. Assigning a service member to a unit that is too small or too large reduces command utility. In contrast, most service members maximize their utility by obtaining the largest and most desirable unit possible. Therefore we maximize the command utility, not the service members' utility.

We make several assumptions in describing the local commands' utility for military housing. First we assume that new housing is better than renovated housing. Therefore, assignments to new housing units earn more utility than assignments to renovated housing units. We assume that the commands do not prefer to house one category of service members at the expense of another, so command utility does not vary with service member rank, number of dependents, or branch of service. Thus, assigning a field grade officer with one dependent to housing earns the same command utility as assigning a junior service member with four dependents. We also assume that housing assignments in the near term generate more utility than housing assignments in the future of because the commands' focus on near term housing requirements. We use an eight percent discount rate to calculate the present value of the total command utility (present value = future value / (1+discount rate)^number of time periods).

The SS model's command utility for field grade and company grade officers assigned to new housing units is shown in Table 7. The POM ranked the six most desirable housing assignments for each service member rank and dependent combination in new and renovated housing. The preferred housing assignment earned the maximum utility while least desirable earned almost no utility. New units earn a maximum of ten, while the maximum for renovated units is nine. Ties were allowed between some housing assignments.

Given the abstract and arbitrary nature of command utility, sampling the local commands was the best way to develop the utility function. However, this method has inherent weaknesses. First, it is difficult to maintain consistency of the rankings because there are approximately 320 potential service member-housing combinations. Second, it is difficult to adjust the utility function. While it easy to change individual rankings, doing so without reexamining all of the rankings can skew the utility function. Finally, these rankings are subjective judgments that include many preference factors which are hard to quantify. They reflect the values of the individual making the rankings and could differ for each decision-maker. Because of these weaknesses, the SS model command utility rankings are a source of uncertainty.

	Field Grade Officers				Company Grade Officers			
# dependents	1	2	3	4	1	2	3	4
Senior Officer Quarters								
4 Bedroom House	6.0	6.0	10.0	10.0			0.5	6.0
3 Bedroom House	10.0	10.0	8.5	8.5	0.5	2.0	4.0	6.0
4 Bedroom Duplex	8.5	8.5	8.5	8.5		6.0	6.0	10.0
3 Bedroom Duplex	6.0	6.0	6.0	6.0	6.0	10.0	10.0	8.5
2 Bedroom Duplex	4.0				10.0	8.5	8.5	
4 Bedroom Townhouse	2.0	4.0	4.0	4.0		6.0	8.5	8.5
3 Bedroom Townhouse	4.0	2.0	2.0	2.0	8.5	4.0	4.0	4.0
2 Bedroom Townhouse	0.5				4.0			

Table 7. Steady State Command Utility for Field Grade and Company Grade Officers Assigned to New Housing (Researcher)

D. CONFIGURATION

The SS model is graphically portrayed in Figure 5. The model's inputs include land, existing housing units and projected housing requirements. The decision variables include which parcels of land to buy or sell, how many houses to construct, renovate, or demolish, and how many service members to assign to each type of housing. These decision variables are the basic elements of the privatization strategy. The project's expenses, revenues, and utility numerically describe each privatization strategy's expected results.

The double-headed arrows indicate that the decision variables in the SS model are highly inter-related, forming a circular influence loop. For example, the housing decision variables indicate how many housing units of each type to construct, renovate, or demolish which determines how much land is required. However, the number of houses available to renovate or demolish depends on which parcels of land are retained.

In this configuration the SS model has 5,443 numerical cells. There are 360 decision variable cells, 126 constraint cells, and 5,200 coefficient cells. Solving the model usually requires less than ten minutes on a Pentium II 233 MHz computer.

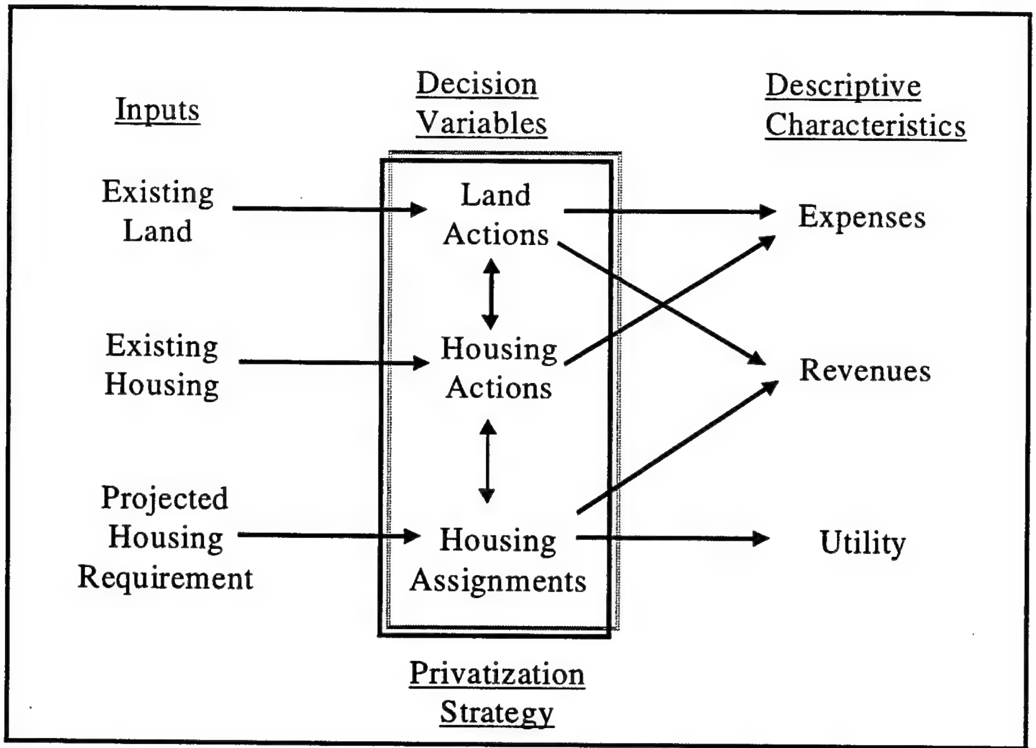

Figure 5. Steady State Model Configuration (Researcher)

E. FORMULATION

This section contains a formulation of the SS model. This formulation is formatted to facilitate reader understanding. The equations are not written in the traditional linear program format, nor are all the equations necessary for a linear program included. Explanations follow the equations.

The number of effective housing years, *EY*, is used to estimate housing costs in each privatization strategy. This coefficient varies with the ratio of new and renovated housing units. This constant summarizes the previously discussed assumptions about construction and renovation rates during the first ten years. The number of effective housing years equals the total number of housing units available for assignment during the entire project divided by the sum of the newly constructed housing units and renovated housing units. For instance, if all new housing is built in the first year and no old housing is renovated the number of effective housing years would be between 30 and

29. This is because the new housing units are available for 29 years and the unrenovated housing units, which are fewer in number than the new units, are available for one year. However, if the new housing construction and renovation is spread over a number of years the number of effective housing years is something less than 29 because most of the new units do not become available for several years. The number of effective housing years for the ten strategies evaluated with the SS model ranged from 27.79 to 28.80. The average number of effective housing years is 28.15.

Indices:

b: plots of land that can be acquired (Seaside 1, Monterey County 9, Monterey County 10),

c: existing community facilities on the POM Annex (library, Child Development Center, youth center, fire station, chapel),

h: housing type including renovated and new housing; e.g. $h = 1$ is a renovated junior enlisted two bedroom housing unit, and $h = 28$ is a new senior officer four bedroom housing unit,

j: service member category, by rank groups and number of dependents, e.g. $j = 1$ is an IET service member with no dependents, and $j = 35$ is a senior officer with four dependents,

s: POM Annex plots of land that can be sold (Stilwell 1 to 4, Hayes East and West, Fitch 1 and 2, and Marshall 1 and 2),

t: year, t=1,...,30.

Data:

B_j = annual BHA for service member type j,

C_h = annual cost of maintaining and operating a single housing unit of type h,

CD_t = cost of debt in year t,

CQ_h = cost of constructing a single housing unit of type h,

CR_h = cost of renovating a single housing unit of type h,

CS_h = cost of demolishing a single housing unit of type h,

EY = number of effective housing years,

HN_j = minimum housing requirement for service member type j,

HX_j = maximum housing requirement for service member type j,

LA_b = acres of land in plot b available for acquisition,

LA_s = acres of land in POM Annex plot s,

LR_h = acres of land required for structure type h,

LV_b = value per acre of plot b,

LV_s = value per acre of POM Annex plot s,

WR_c = annual acre-feet of water required for existing community facility c,

WR_h = annual acre-feet of water required for structure type h,

WA = MBMH acre-feet water allotment,

WS = acre-feet of water attached to each acre of land sold,

$U_{h,j}$ = command utility per service member type j for structure h.

Decision Variables:

Q_h = number of housing units of type h to construct,

R_h = number of housing units of type h to renovate,

S_h = number of housing units of type h to demolish,

T_s = portion of plot s to sell,

V_b = portion of plot b to acquire,

$X_{h,j}$ = number of service members of type j to assign to housing type h,

Steady State Model:

(1) Maximize $\sum_{h,j} U_{h,j} X_{h,j}$

subject to:

(2) $EY \sum_{h,j} B_j X_{h,j} + \sum_s LV_s T_s \geq \sum_h \left(CQ_h Q_h + CR_h R_h + CS_h S_h \right) + EY \sum_h C_h \left(Q_h + R_h \right) + \sum_b LV_b V_b + \sum_t CD_t$

(3) $\sum_s LA_s \left(1 - T_s \right) + \sum_b LA_b V_b \geq \sum_h LR_h \left(Q_h + R_h \right) + \sum_s LA_s T_s$

(4) $WA \geq \sum_h WR_h \left(Q_h + R_h \right) + \sum_c WR_c + WS \sum_s LA_s T_s$

(5) $HX_j \geq \sum_h X_{h,j} \geq HN_j$ for all j

(6) $\left(Q_h + R_h \right) \geq \sum_j X_{h,j}$ for all h

Explanation of objective function and constraints:

Equation (1): Maximize the military housing command utility.

Equation (2): At the end of the project the revenue from service member's BHA and land sales must be greater than the expenses for housing, land purchases, and debt interest charges.

Equation (3): At the end of the project the total amount of land retained and purchased must exceed the total amount of land required for new housing, renovated housing, and land sales.

Equation (4): At equilibrium the annual water allotment must exceed the sum of the annual water requirement for housing, community facilities and land sales.

Equation (5): For each service member category the housing assignments must not exceed the maximum requirement and may not be less than the minimum requirement at equilibrium.

Equation (6): For each housing type the number of renovated and new housing units must equal or exceed the number of housing assignments.

F. OPTIMIZATION

We used the *What's Best?* application to optimize several different privatization strategies that are being considered by the local commands. These alternative strategies included different land use plans and different levels of cooperation between the NPS and the POM. We modeled each strategy by changing some of the SS model's initial data and fixing some decision variables. The cost estimates, resource factors, and housing requirements were held constant. The optimization results predict each strategy's best possible performance.

Because the privatization strategies have different housing requirements we used the average utility per housing unit to compare the strategies' performance. The highest possible score is ten because the highest utility possible for new housing assignments is ten. The maximum score for revitalized housing is nine points. Therefore, if a strategy's score is near ten most of the personnel are assigned to new housing. However, if the average score is below eight, it indicates that a significant portion of the personnel are assigned to revitalized housing that is not the appropriate size or type. In some cases we also measured the number of assignments to a housing unit that is significantly less than

Privatization Strategy	Rank	Avg. Utility	Land Actions	Participants	Avg. BHA ($)	Annual Rev. ($k)	Comments
Sell most of existing housing, revitalize remaining housing, and build new units.	1	9.468	Sell Hayes and Stilwell 1,2,3,4, w/ replacement.	POM and NPS (600)	$ 904	$21,840.0	Over 120 undesirable assignments.
Separate from NPS, revitalize existing housing and build additional units.	2	9.299	Give Stilwell 1,2,3 to NPS; sell Hayes and Stilwell 4 w/o replacement; buy Seaside 3 and Monterey County 9.	POM only	$ 859	$14,570.0	Over 100 undesireable assignments.
Divide existing housing with NPS, revitalize the remaining housing and build additional unts.	3	9.235	Give Stilwell 1,2 to NPS; sell Hayes and Stilwell 4 w/ replacement.	POM only	$ 859	$14,570.0	Over 50 undesireable assignments.
Revitalize some existing housing and build additional units.	4	9.183	Sell Hayes, Stilwell 4 and Marshall 1 w/o replacement.	POM and NPS (1250)	$ 960	$30,689.0	Over 50 undesireable assignments.
Revitalize all existing housing and build additional units.	5	8.975	Sell Hayes and Stilwell 4 with replacement.	POM and NPS (600)	$ 904	$21,840.0	Over 220 undesirable assignments.
Divide existing housing with NPS, revitalize the remaining housing and build additional units.	6	8.958	Give Stilwell 1,2,3 to NPS; Sell Hayes and Stilwell 4, w/ replacement.	POM only	$ 859	$14,570.0	Over 200 undesirable assignments.
Separate from NPS, revitalize existing housing and build additional units.	7	8.85	Give Stilwell 1,2,3 to NPS; sell Hayes and Stilwell 4, w/o replacement; buy Seaside 3.	POM only	$ 859	$14,570.0	Over 380 undesirable assignments.
Revitalize all existing housing and build additional units.	8	8.811	No actions.	POM and NPS (600)	$ 903	$21,860.0	Over 300 undesirable assignments.
Revitalize all existing housing and build additional units.	9	8.562	No actions.	POM and NPS (1250)	$ 960	$30,690.0	Over 900 undesirable assignments.
Revitalize all existing housing and build additional units.	10	8.201	Sell Hayes and Stilwell 4 w/o replacement.	POM and NPS (600)	$ 904	$21,840.0	Over 800 undesirable assignments.
Separate from NPS, revitalize existing housing and build additional units.	11	5.04	Give Stilwell 1,2,3 to NPS; sell Hayes and Stilwell 4 w/o replacement.	POM only	$ 858	$14,400.0	Over 900 undesirable assignments.

Table 8. Steady State Model Optimization Results (Source: Developed by Researcher)

desired. This would include assignments to a less desirable type and size of housing, or assignments to housing that is two sizes too small.

Portions of the SS model optimization results are shown in Table 8. The plots of housing land at POM Annex include Hayes, Stilwell 1 to 4, Marshall 1 & 2, and Fitch 1 & 2. The plots of land available for acquisition include Seaside 3, and Monterey County 9 & 10. The note "w / replacement" means equal number of acres provided by purchasing organization. The note "w/o replacement" indicates that no replacement land is provided by the purchasing organization. The NPS participation column indicates the number of housing units that are occupied by the NPS.

G. STEADY STATE MODEL CONCLUSIONS

We drew several conclusions from the optimization results. First, land is the limiting factor in the MBMH project. The MBMH project must acquire additional land if it is to satisfactorily meet all future housing requirements in the Monterey Bay area. In each strategy a significant number of families are assigned to the incorrect size or type of housing because there is not enough land to build the right type of housing. In some cases the model even replaced single family houses with several smaller housing units.

Because land is the limiting factor, all of the land assumptions and data are critical. The cost estimates, land usage rates, acres per plot, and infrastructure requirements have a large impact on the model's results.

The SS model also demonstrated that the funding constraint is important, but is not the limiting constraint. In several cases the model demolished larger single family homes to build townhouses and duplexes that required less land. This indicates that the model ran out of land before it ran out of money. It also appears possible that the MBMH project could have surplus funding at the end of a 30 year contract. Therefore the MP model needed to include a mechanism to accrue interest on project surpluses.

We concluded that the MBMH should include as much of the NPS housing requirements as possible. The NPS's large number of mid-grade officers significantly

raise the average BHA (rent) per housing unit. The average BHA for the Army alone is $859. When the project includes 600 NPS housing units the average BHA is $904. The highest average BHA of $960 occurs when the NPS fully participates by occupying 1,250 units. We assume that the higher BHA will enable the contractor to provide better housing. Including the NPS in the MBMH project also increases the project's annual revenue. The annual revenue with the POM alone would be about $14.6 million. If the NPS occupies 600 housing units the annual revenue increases to $21.8 million. The annual revenue peaks at $30.7 million when the NPS occupies 1250 units. The higher annual revenue will increase the MBMH project's leverage during contract negotiations and decrease the time needed to repay accrued debt. In essence, buying in bulk is more efficient.

The analysis also indicates that the best strategy identified by the MBMH project is to sell a large amount of the POM Annex housing land, revitalize the retained housing and buy additional land to build new housing to meet most of the requirements. (See Table 8.) This strategy has a score of 9.47, indicating that a large portion of the service member population is in new housing of the right type and size. However, it includes approximately 120 unsatisfactory housing assignments and includes only one-half of the NPS housing requirements.

The fourth ranking strategy includes all of the NPS housing requirements (1,250 units), has a slightly lower score of 9.18, and only 50 unsatisfactory assignments. This strategy sells part of the POM Annex and builds new housing on newly acquired land. Approximately one-third of the assignments involve new housing units. An additional benefit, not reflected in the average utility score, is that this strategy has the highest annual revenue and average BHA.

IV. MULTIPLE PERIOD MODEL

Although the Steady State model identifies the optimal housing mix for the MBMH program at equilibrium it does not indicate how to achieve that mix. Considering the large number of decision variables involved there could be many feasible methods to achieve the optimal mix. Thus the MBMH planners need a model that can determine the optimal housing actions year by year. The planners also need detailed yearly financial and performance estimates for each strategy under consideration. Finally, the planners must be able to adjust the yearly service member population. The objective of the Multiple Period (MP) model is to identify the optimal housing actions year by year and to provide detailed performance estimates.

A. MUTLIPLE PERIOD MODEL ASSUMPTIONS

The MP model makes the same assumptions as the SS model, unless specified below. The SS model assumptions are discussed in section III.A.

Like the SS model the MP model assumes that all housing actions will be completed in ten years. A sensitivity analysis indicated that as long as the maximum allowable debt is $25 million or more all land and housing actions are completed by the ninth year, indicating that this assumption holds for maximum debts of $25 million or more. However, when the maximum debt was less than $25 million all land and housing actions are completed in the tenth year, which is the last year any action is allowed. Therefore, we cannot conclude that this assumption holds for a maximum debt of less than $25 million.

Ideally we would model each year of the MBMH individually to determine if the ten year time limit constrains the optimal privatization strategy. Due to numerical problems the largest model we were able to solve used 24 individual time periods. In this expanded model all housing and land actions were completed in the fourth year with a

maximum debt of $233 million. Modeling the last six years individually probably would not change the optimal strategy much because the utility earned during the last six years is less than 7% of the total command utility.

The MP model makes the following assumptions about community facilities. All existing community facilities can be demolished to make room for other structures, or sold with the land they occupy. Several desirable new community facilities, determined by the POM, may be constructed during the first ten years. This set of optional community facilities includes a jogging path, sports center, guest lodge, and swimming pool. The only facility that must be replaced if sold or demolished is the Child Development Center (CDC). The library, chapel, fire station, and youth center do not have to be replaced if they are demolished. The Post Exchange and commissary cannot be demolished or sold.

We assume that military personnel living in military housing are the main users of the military community facilities; those living off-post probably use them less than those in military housing because they do not live as close to the community facilities. Therefore all community facilities earn utility in proportion to the number of military families in military housing.

We assume that the community facilities are important to the local commands but are not as important as the housing units. Therefore we assigned relatively low utility rates to the community facilities as compared to the housing assignments. The sports center and new CDC have the highest utility rate of the community facilities at 0.4 per assigned family because they are the most used facilities. The guest lodge and community center have the lowest utility rates at 0.05 because service members will use these less than the other community facilities. We also assume that housing residents without children would not use the community facilities that focus on children. Therefore the CDC, youth center, super playground, and Fun Zone do not earn utility for housing units assigned to service members without children. Under these assumptions the community facility utility is 17 to 20% of the total command utility in each of the ten strategies we evaluated.

We assume that all housing construction, renovation and demolition will be spread throughout each year because breaks cause personnel, material, and equipment requirements to fluctuate and increase the cost per housing unit. Therefore some of the construction will be completed early in the year and some housing units will be available for assignment the remainder of the year.

Assuming it takes six months to build a new housing unit, the production could be divided into two batches. If 12 units were built in one year, six would be completed in June and six would be completed in December. The six completed in June would be available for assignment for one-half a year, producing a total of three unit-years of housing. Therefore, approximately 25% of the housing to be constructed in a year will be available for use during that year. Similarly, we assume that demolition will take six months, including administrative lead-time, so that 25% of the houses to be demolished in a year are available for assignment.

We assume that it will take four months to renovate an existing unit; if 12 units are to be renovated in one year, four units would be renovated every four months. The first set would be available as renovated units for the last eight months producing eight-thirds of renovated housing years. The second set would be available as unrenovated for four months producing four-thirds unrenovated years, and for four months as renovated producing an additional four-thirds renovated housing years. The last set would be available for eight months as unrenovated producing eight thirds unrenovated housing years. Thus, renovating 12 housing units in one year produces four unrenovated and four renovated housing years in that year, with renovations consuming four housing years. Therefore we estimate that for any number of units to be renovated in one year 33% will be available as unrenovated, 33% will be available as renovated units, and 33% will be unavailable.

These factors are accurate for each year as a whole but misrepresent the actual housing availability in individual months. In the previous construction example the model estimates that three newly constructed houses are available throughout the entire year when actually six units were available only during the last half of the year. Thus, the

MP model overestimates the new housing available in the first half of each year and underestimates the new housing available in the later half of each year. These inaccuracies at the monthly level of analysis are unavoidable because the MP model's unit of time is one year.

An alternative assumption is that all housing units under action are not available until the year's end even though it does not take a year to complete the action. This assumption would cause the MP model underestimate the housing available and build extra housing. A better alternative is to decrease the model's unit of time from one year to six months. Unfortunately, this would double the number of variables in the MP model and lead to unacceptable solution times.

The MP model assumes that all available parcels of land can be sold or acquired in pieces over several years. This assumption enables the MBMH to acquire land as needed and convey existing housing lands to the public when no longer needed. We also assume that the price of the land for sale or acquisition will not change from year to year. In the MP model land is sold "as is" and is acquired with all necessary improvements. The NPS and POM housing land is not for sale.

Given the current housing shortage we assume that the MBMH project may not be able to meet the minimum housing requirement for the first several years until additional housing units can be constructed. Therefore we relaxed the minimum housing requirements by 25% for the first ten years to ensure that a feasible solution can be found. The MP model must meet or exceed the minimum housing requirement after year ten.

The MP model assumes that service members can move from one housing unit to another cost free. Because the model reassigns every service member each year and cannot track individual service members the model cannot determine if service members are moving from one housing unit to another each year. In reality such moves are expensive and would not be acceptable. Prohibiting these moves may delay the revitalization process, requiring more time to reach equilibrium, and reduce total project utility.

Unlike the SS model, the MP model does not charge water, utility (gas and electricity), and maintenance costs for unassigned housing units. Incurring these costs for vacant units would incentivize the model not to have unused housing units. This allows the MP model to leave some of the existing housing units unrenovated and unused. It also gives the MP model the flexibility to construct or renovate housing units prior to when they are needed if that is more cost effective. The SS model could not leave housing units vacant or renovate them before they are needed because it assumes that all existing housing must be renovated or demolished and that all housing units incur operating costs.

Based on input from the local commands, we assume that the new and renovated housing will enable contractors to achieve additional efficiencies that will reduce the average annual maintenance cost. Therefore, the annual maintenance cost in the MP model was set at $2,000 per housing unit, instead of $3,000 as in the SS model.

B. DATA

We use real numbers for the community facility decision variables because integers would significantly increase the model's solution time. MBMH project planners will have to adjust the MP model results to eliminate the partial construction of community facilities. This will cause a slight change in each privatization strategy's utility score and financial figures.

Because the SS model identified land as a limiting constraint we revised the land calculations to improve the MP model's accuracy. The SS model ensures that the land requirements for all land uses do not exceed the total land available. The MP model calculates land requirements only for new construction. It ensures that the land requirements for all new facilities do not exceed the unused land available, which includes unused land in retained parcels and newly acquired land. In most cases this reduces the MP model's uncertainty because amount of land included in the land use calculations is significantly smaller, reducing the size of potential errors.

We revised the infrastructure overhead rate from the SS model after reexamining existing infrastructure requirements at the POM Annex. We assume that most of the new housing units will be constructed on newly acquired land near the POM Annex and that infrastructure requirements will be similar to those in the existing POM Annex housing areas. This assumption slightly overestimates the infrastructure requirement for the NPS housing areas, which is predominantly townhouses with much less greenspace. This inaccuracy is acceptable because the NPS housing constitutes less than 30% of the privatized housing units.

Because the SS model indicated that the optimal strategy is to sell the POM Annex land we also revised commercial land values by sampling local real estate property listings. In the MP model we estimate the POM Annex housing land to be worth approximately $500,000 per acre, which is nearly twice as much as in the SS model. On 5 July 1998 seven single-family homes for sale in the adjacent community of Seaside had an average list price of $196,000 (*Monterey County Herald*, 5 July 1998). One estimate is that in 1995 land accounted for 34% of house prices in California (Boyer, 1995). Using this estimate, and assuming that the average lot size is one-eighth of an acre, the land in the adjacent communities is valued at $533,000 per acre. We assume that the land will be sold as is, with all existing structures.

Similarly we used the advertised price of several undeveloped plots of land to estimate the value of the Monterey County and Seaside parcels of land. This land is significantly less valuable because it is does not have a view of the bay, is not adjacent to the golf courses, and does not include a water allotment. We estimate that the MBMH project could acquire the Seaside and the Monterey County land for $60,000 to $70,000 per acre.

The MP model gradually increases the NPS housing requirement to 1,250 units during years two through six. The gradual growth better reflects the NPS's best estimate of future housing requirements than the SS model's uniform housing requirements. In several of the privatization strategies the NPS requirement of 1,250 from the first year caused the SS model to overestimate the housing requirement during the first five years.

The MP model housing requirements incorporate the POM's command objective to provide more housing units for those service members least able to afford housing in local rental markets. We modeled this by increasing the local commands' desired housing level for junior enlisted, IET, and company grade officers to 95%. Thus the MP model will provide up to an additional 5% of housing for these service member groups when justified by the marginal utility.

The MP model computes a weighted average for each service member group BHA because the service member groups (POM, NPS, and independent units) have significantly different rank distributions and change size independently. First, a weighted average for BHA is calculated for each housing category (IET, JE, etc.) within each service member group (POM, NPS, and independent units) baseline population. Then an average BHA for the MBMH project in each year is calculated by taking a weighted average of the service member groups in each housing category for that year. This enables the MBMH project's annual BHA to change from year to year as the service member groups expand or contract. This also gives each rank an equal chance of being assigned housing when there is a shortage of housing units. This is a better approximation of actual housing practices than the SS model's assumption that the lowest ranks are always assigned housing first. A weighted average is also the most accurate way to calculate the annual BHA revenue, given that the MP model cannot individually track service members.

C. COMMAND UTILITY FUNCTION

We implemented a new command utility function for the MP model to improve the model's logical consistency and flexibility. The MP model's increased detail exacerbated the shortcomings of the SS model's command utility function. Using the same mechanism in the MP model would have required local commands to rank approximately 480 potential individual assignments because the MP model includes unrenovated units. This would have been a very tedious and difficult task.

The MP model defines the command utility for a range of possible housing assignments for housing category in a Standard Utility Function (SUF). (See Table 9.) The SUF includes 25 possible assignments to a housing unit that is two types (senior officer to junior enlisted) and/or two sizes (two bedroom to four bedroom) different from the desired housing assignment. Each possible assignment earns a percentage of the maximum utility and is described by its difference in size and type from the optimal assignment. The desired assignment has a utility of 100%. The percentage of utility earned decreases as the distance from the optimal assignment increases. Assignments that are unacceptable to the local commands have a negative utility, which prevents the MP model from making highly undesirable assignments unless they are justified by significant benefits.

Type/Size	-2	-1	0	+1	+2
+2	0.0%	-15.0%	-30.0%	-45.0%	-60.0%
+1	60.0%	50.0%	30.0%	10.0%	-10.0%
0	60.0%	85.0%	100.0%	90.0%	65.0%
-1	-20.0%	10.0%	30.0%	45.0%	60.0%
-2	-70.0%	-50.0%	-30.0%	-10.0%	0.0%

Table 9. Multiple Period Model Standard Utility Function (Researcher)

The Command Utility Function (CUF) is the product of the SUF and the maximum command utility for each type of housing (new, renovated, and unrenovated). (See Table 10.) In the MP model the maximum command utility for new, renovated, and unrenovated housing is ten, seven and five respectively. In the SS model the maximum utility was ten for new housing and nine for renovated housing. The increased range of maximum utilities for the housing types better reflects the commands' strong preference for new housing and dissatisfaction with the existing housing.

The MP model's utility function is easier to change than the SS model's because any change to the SUF changes the CUF for all three housing types. Additionally, the relative value of new, renovated and unrenovated housing can be modified by changing the maximum utility for each type of housing. In the SS model each of these changes

would require changing the utility of at least 100 potential housing assignments. More importantly, it is easier to maintain the logical consistency of the MP command utility function because the SUF requires only 25 rankings as opposed to several hundred in the SS model.

Type/ Size	New Unit -2	-1	0	+1	+2	Revitalized Unit -2	-1	0	+1	+2	Unrevitalized Unit -2	-1	0	+1	+2
+2	0.0	-0.8	-1.5	-2.0	-3.0	0.0	-1.1	-2.1	-3.2	-4.2	0.0	-1.5	-3.0	-4.5	-6.0
+1	6.0	5.0	3.0	1.0	-0.5	4.2	3.5	2.0	0.7	-0.7	3.0	2.5	1.5	0.5	-1.0
0	6.0	8.5	**10.0**	9.0	6.5	4.2	6.0	**7.0**	6.3	4.6	3.0	4.3	**5.0**	4.5	3.3
-1	-1.0	1.0	3.0	4.5	6.0	-1.4	0.7	2.1	3.2	4.2	-2.0	0.5	1.5	2.3	3.0
-2	-3.5	-2.5	-1.5	-0.5	0.0	-4.9	-3.5	-2.1	-0.7	0.0	-7.0	-5.0	-3.0	-1.0	0.0

Table 10. Multiple Period Model Command Utility Function (Researcher)

D. CONFIGURATION

The MP model configuration is graphically portrayed in Figure 6. The inputs and decision variables are the same as the SS model, except for the addition of community facilities. All decision variables and descriptive characteristics in the MP model are indexed by time because the MP model computes results for each year.

The MP model requires more constraints than the SS model because many of the MP model constraints must be applied on a yearly basis, whereas the SS constraints only apply the project totals at year 30. For instance the water and land constraints apply to each year in the MP model, but only apply to the SS model's final status. The MP model must also meet a minimum housing requirement in every year, unlike the SS model where the minimum housing requirement must be maintained only after equilibrium is achieved. An additional constraint that applies specifically to the MP model involves an upper limit on cumulative land sales. An example is that the sum of the portions of a lot sold in each year throughout the project's 30 years cannot exceed the lot's initial size.

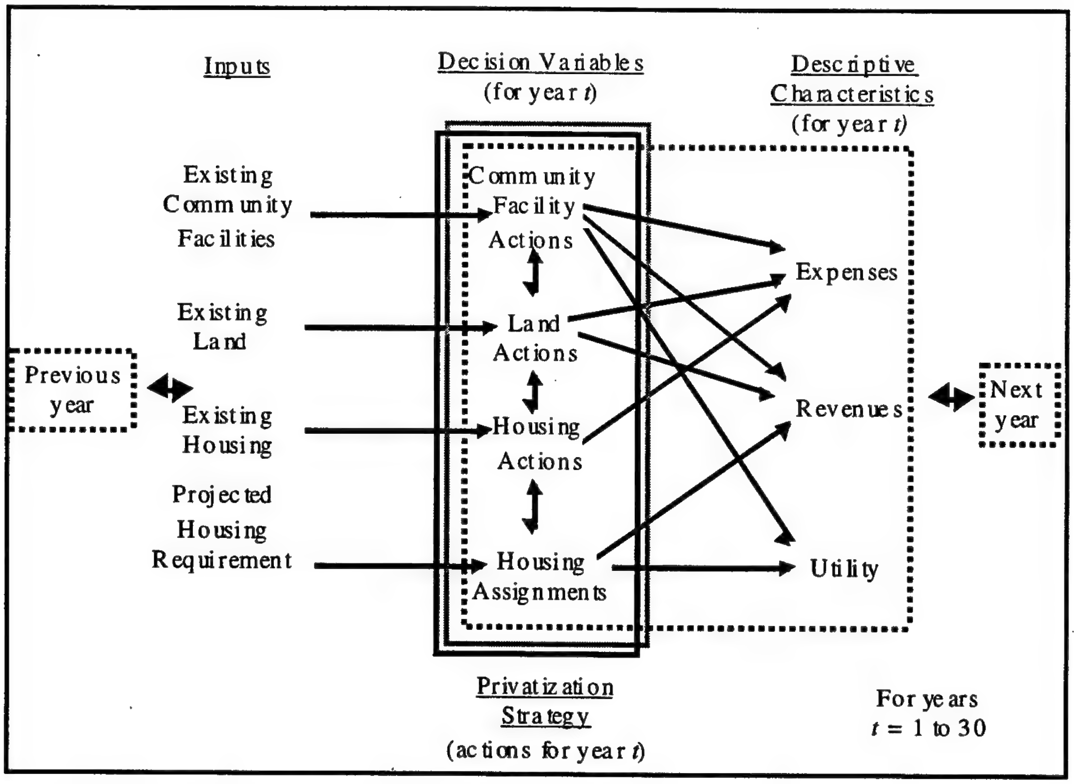

Figure 6. Multiple Period Model Configuration (Researcher)

Like the SS model many of the MP model's decision variables and constraints are interrelated. For instance the water and land constraints in each year are the result of all previous years water and land decision variables. The MP model simultaneously optimizes all of these constraints and decision variables, although Figure 6 indicates they are sequential.

The MP model has 19,983 numeric cells, including 4,791 adjustable cells for decision variables and 1,816 cells for constraints. The model solves in fifteen minutes to one hour using a Pentium II 233 MHz computer depending on the modeled strategy.

E. FORMULATION

A formulation of the MP model follows. As with the SS model this formulation is formatted to facilitate reader understanding and all constraints necessary to execute a linear program are not included. Explanations follow the equations.

Indices:

b: plots of land that can be acquired (Seaside 3, Monterey County 9, Monterey County 10),

c: existing community facilities on the POM Annex (library, Child Development Center, youth center, fire station, chapel),

h: housing type including new, renovated, and unrenovated, e.g. $h = 1$ is an unrenovated two bedroom junior enlisted housing unit, and $h = 41$ is a new four bedroom senior officer housing unit,

j: service member category, by rank groups and number of dependents, e.g. $j = 1$ is an IET service member with no dependents, and $j = 35$ is a senior officer with four dependents,

n: desired new community facilities on the POM Annex (library, Child Development Center, Putt Putt golf course, sports center, swimming pool, guest lodge, super playground, exercise trail, Fun Zone),

s: POM Annex plots of land that can be sold (Stilwell 1 to 4, Hayes East and West, Fitch 1 and 2, and Marshall 1 and 2),

t, t': year, t=1,…,30.

Data:

B_j = annual BHA for service member type j,

C_h = annual cost of maintaining and operating a single housing unit of type h,

CQ_h = cost of constructing a single housing unit of type h,

CR_h = cost of renovating a single housing unit of type h,

CS_h = cost of demolishing a single housing unit of type h,

CY_n = cost of building new community facility n,

CZ_c = cost of demolishing existing community facility c,

HN_j = minimum housing requirement for service member type j,

HX_j = maximum housing requirement for service member type j,

I_d = interest rate on project debt D_t,

I_e = interest rate on project surplus E_t,

LA_b = acres of land in plot b available for acquisition,

LA_s = acres of land in POM Annex plot s,

LR_c = acres of land required for community facility c,

LR_h = acres of land required for a single housing unit of type h,

LR_n = acres of land required for community facility n,

LV_b = value per acre of plot b,

LV_s = value per acre of POM Annex plot s,

$OH_{h,s}$ = initial on-hand quantity of type h housing units on parcel s,

$PV_t = 1 / (1+.8)^t$ (this is a standard present value equation with an 8% discount rate)

RD = interest rate on annual debt,

RE = interest rate on annual surplus,

U_c = utility for old community facility c, per service member assigned to housing,

$U_{h,j}$ = utility per service member type j assigned to housing type h.

U_n = utility for new community facility n, per service member assigned to housing,

WR_c = annual acre-feet water requirement for community facility c,

WR_h = annual acre-feet water requirement for a single housing unit of type h,

WR_n = annual acre-feet water requirement for community facility n,

WA = MBMH acre-feet water allotment,

WS = acre-feet of water attached to each acre of land sold,

Decision Variables:

D_t = project debt at end of year t,

E_t = project surplus at the end of year t,

$G_{h,t}$ = number of housing units of type h to give away in land sales in year t,

$N_{h,t}$ = number of initial housing units of type h remaining unrenovated in year t,

$Q_{h,t}$ = number of housing units of type h to construct in year t,

$R_{h,t}$ = number of housing units of type h to renovate in year t,

$S_{h,t}$ = number of housing units of type h to demolish in year t,

$T_{s,t}$ = fraction of plot s to sell in year t,

$V_{b,t}$ = fraction of plot b to acquire in year t,

$X_{h,j,t}$ = number of service members of type j to assign to housing type h in year t,

$Y_{n,t}$ = fraction of community facility n to build in year t,

$Z_{c,t}$ = fraction of old community facility c to demolish in year t,

Multiple Period Model:

(1) Maximize
$$\sum_{h,j,t} U_{h,j} X_{h,j} PV_t + \sum_{n,t} U_n PV_t \left(\sum_{t'=1}^{t} Y_{n,t'} \sum_{h,j} X_{h,j,t} \right) + \sum_{c,t} U_c PV_t \left(\sum_{t'=1}^{t} Z_{c,t'} \sum_{h,j} X_{h,j,t} \right)$$

subject to:

(2a)
$$\sum_{h,j,t} B_j X_{h,j,t} + \sum_{s,t} LV_s T_{s,t} + \sum_t IE_t \geq \sum_{h,t} \left(CQ_h Q_{h,t} + CR_h R_{h,t} + CS_h S_{h,t} \right) + \sum_{n,t} CY_n Y_{n,t} + \sum_{c,t} CZ_c Z_{c,t} + \sum_{h,t} C_h \sum_j X_{h,j,t} + \sum_{b,t} LV_b V_{b,t} + \sum_t ID_t$$

(2b) $IE_t = ID_t = 0$ for $t = 1$

(2c) $ID_t = RD * D_{t-1}$ for $t = 2$ to 30

(2d) $IE_t = RE * E_{t-1}$ for $t = 2$ to 30

(3a)
$$\sum_{t'=1}^{t} LA_s\left(1-T_{s,t'}\right)+\sum_{t'=1}^{t} LA_b V_{b,t'} \geq \sum_{t'=1}^{t} LR_n Y_{n,t'}+\sum_{c} LR_c\left(1-\sum_{t'=1}^{t} Z_{c,t'}\right)+$$
$$\sum_{h} LR_h\left(\sum_{t'=1}^{t} Q_{h,t'}+\sum_{t'=1}^{t} R_{h,t'}+N_{h,t'}\right) \quad \text{for all } t$$

(3b)
$$N_{h,t}=\sum_{s} OH_{h,s}\left(1-T_{s,t}\right)-\sum_{t'=1}^{t} R_{h,t}-\sum_{t'=1}^{t} S_{h,t} \quad \text{for all } t,h$$

(4a)
$$WA \geq \sum_{h,t} WR_h\left(\sum_{t'=1}^{t} Q_{h,t'}+\sum_{t'=1}^{t} R_{h,t'}+N_{h,t}\right)+\sum_{n}\sum_{t'=1}^{t} WR_n Y_{n,t'}$$
$$+\sum_{c} WR_c\left(1-\sum_{t'=1}^{t} Z_{c,t'}\right)+WS\sum_{s} LA_s T_{s,t} \quad \text{for all } t=1 \text{ to } 10$$

(4b)
$$WA \geq \sum_{h,t} WR_h\left(\sum_{t'=1}^{t} Q_{h,t'}+\sum_{t'=1}^{t} R_{h,t'}\right)+\sum_{n,t'=1}^{t} WR_n Y_{n,t'}$$
$$+\sum_{c} WR_c\left(1-\sum_{t'=1}^{t} Z_{c,t'}\right)+WS\sum_{s} LA_s T_{s,t} \quad \text{for all } t=11 \text{ to } 30$$

(5a) $HX_{j,t} \geq \sum_{h} X_{h,j,t}$ for all j,t

(5b) $\sum_{h} X_{h,j,t} \geq HN_{j,t}$ for all j,t

(6a) $\sum_{t'=1}^{t} \left(Q_{h,t'} + R_{h,t'}\right) + N_{h,t} \geq \sum_{j} X_{h,j,t}$ for all h, t=1 to 10

(6b) $\sum_{t'=1}^{t} \left(Q_{h,t'} + R_{h,t'}\right) \geq \sum_{j} X_{h,j,t}$ for all h, t=11 to 30

Explanation of objective function and constraints:

Equation (1): Maximize the sum of the command utility from all housing assignments, new community facilities, and old community facilities.

Equation (2a): At project completion the sum of the revenue from service member BHA, land sales, and interest earned on surplus must exceed the sum of the housing construction, renovation, and demolition plus the new community facility construction costs plus the old community facility demolition costs plus housing maintenance costs plus the land acquisition costs plus the interest charges on project debt.

Equation (2b): The interest charges and revenues in the first year are zero.

Equation (2c): The interest charges in year t are the product of the interest rate on debt RD and the project debt from the prior year D_{t-1} for years 2 to 30.

Equation (2d): The interest revenue in year t is the product of the interest rate on surpluses RS and the project surplus from the prior year E_{t-1} for years 2 to 30.

Equation (3a): The sum of the retained land and acquired land must exceed the sum of land requirements for all new community facilities, retained community facilities, and housing units in all years.

Equation (3b): The unrenovated housing on hand equals the initial on-hand inventory not sold with land minus renovated and demolished housing units in all years.

Equation (4a): In years one to 10 the water allotment must exceed the sum of water requirements for new, renovated and unrenovated housing plus new community facilities plus retained old community facilities plus water sold with land.

Equation (4b): In years 11 to 30 the water allotment must exceed the sum of water requirements for new and renovated housing plus new community facilities plus retained old community facilities plus water sold with land.

Equation (5a): The total assignments for each service member group cannot exceed the maximum requirement for that group in each year.

Equation (5b): The total assignments for each service member group must be equal to or greater than the minimum requirements for that group in each year.

Equation (6a): The sum of all new, renovated and unrenovated housing units must exceed the housing assignments for each type in years one to 10.

Equation (6b): The sum of all new and renovated housing units must exceed the housing assignments for each type in years 11 to 30.

F. OPTIMIZATION

We optimized the MP model to identify the privatization strategy that will produce the highest total command utility for the MBMH project. We included a range of maximum debt and commercial land values to determine their impact on the MBMH project. We also investigated the impact of political limitations such as not being able to sell or acquire land.

We used five performance metrics to compare different privatization strategies. (See Table 11.) The "total utility" is the present value of all command utility earned by the family housing assignments and community facilities. The "average utility" is the average real (not discounted) command utility per housing assignment, not discounted to the present value. To focus on the commands' satisfaction with family housing the average utility metric excludes all utility from community facilities. The "% new units" is the percent of the final housing inventory that are new housing units. The final housing

inventory does not include unrenovated units that are not available for assignment. "Years to Revitalize" is the number of years it takes to complete all housing construction or renovation. We also note which new community facilities are constructed and when the construction is completed.

All factors other than the maximum debt and the value of the POM Annex land were held constant. Unless noted otherwise all optimization results are based on a $500,000 per acre value for all POM Annex land. Although future housing requirements may change, as a result of increased enrollments or a drawdown, we did not optimize the project with different housing requirements. Based on the SS model results, which indicate that the MBMH project benefits from NPS participation, all NPS existing housing assets and housing requirements are included in the MP model. All of the data used during the MP model optimization is listed in Appendix A.

1. Optimal MBMH Privatization Strategy

The optimal MBMH privatization strategy is to acquire additional land, build new housing units, and then sell most of the POM Annex housing land. (See Table 11.) This strategy has the highest total command utility and the highest average utility per housing unit. It replaces all the existing housing with new housing units (except historical units), includes all of the possible new community facilities, and resolves the MBMH housing issues in the least amount of time (three years).

This strategy nearly achieves the theoretical maximum command utility. The theoretical maximum would be achieved if all new housing could be constructed before the project begins. In this strategy the command utility is slightly less than theoretical maximum because this strategy takes two years to construct new housing for all the service members. The average utility per housing unit is also less than the theoretical maximum of ten because the maximum utility for historical housing units, which must be retained, is seven. The command utility from community facilities can not be improved because all new community facilities are completed the first year.

The optimal strategy yields the highest command utility because it fully leverages the commercial value of the POM Annex land. In the first year it incurs $233 million in

debt to acquire all necessary land, build almost 2000 housing units, and construct all new community facilities. In the second year it demolishes approximately 720 housing units to make room for another 400 new housing units. In the third year it eliminates half the total debt by selling most of the POM Annex land. By the end of the third year all 51 historic units are renovated and over 2400 new units have been constructed. During the remaining 27 years the project pays off the remaining debt of $116 million.

A slightly different strategy (#2) with a maximum debt of $150 million yields nearly the same results. The total command utility for this strategy is slightly reduced but the project still replaces the entire housing inventory in three years. The only major difference between this strategy and the optimal strategy is that the community facilities are completed in the second year vice the first year. However, limiting the maximum debt significantly reduces interest charges.

Strategy Description	Max. Debt	Total Utility	Avg. Utility	% New Units	Years to Revitalize	Community Facilities
1. Sell POM Annex, Acquire new land	$233 M	317,569	9.78	97.9 %	3	All new in 1st year
2. Sell POM Annex, Acquire new land	$150 M	316,000	9.77	97.9%	3	All new in 2nd year
3. Sell no land, Acquire some land	$93 M	240,451	7.17	37.2 %	9	All new in 1st year, no lodge
4. Sell no land, Acquire no land	$94 M	239,749	7.21	37.5 %	9	All new in 1st year, no lodge

Table 11. Optimal Project Performance of Various Privatization Strategies (Researcher)

Both of these privatization strategies are somewhat unrealistic because they include constructing almost 2000 new housing units the first year and another 400 the second year. Constructing 2000 housing units in a single year would require a tremendous amount of equipment and personnel. The fixed costs associated with obtaining and relocating that amount of equipment and personnel are extremely high. Contractors may have difficulty recruiting enough qualified workers for a single year of work. It is also questionable that the road network could handle the vehicular traffic

required to support constructing 2000 units in one year. A more feasible construction plan is to spread the housing construction over four to five years.

Regardless of the maximum debt level the optimal privatization strategy includes acquiring more land and constructing additional housing units because the MBMH project does not have enough housing to meet requirements and revitalize housing at the same time. This is because service members cannot be assigned to a housing unit while it is renovated or constructed. Therefore the MBMH project needs additional housing assets during the revitalization.

Acquiring additional land is essential to avoiding a housing shortage during the housing revitalization even when it does not seem economical. This is true even if the commercial value of the POM Annex is only $100,000 per acre and the new land costs $60,000, although the $40,000 difference will not cover the cost of replacing the six to ten housing units lost by selling an acre of land. The optimal strategy remains the same because the project needs additional land to meet the housing requirements.

However, in most of the strategies evaluated the optimal land use includes selling more land than is bought, indicating that the MBMH project has enough land to meet its housing requirements after revitalization. In many cases the optimal housing actions leave some housing units unrenovated and unused after the housing inventory is revitalized because the NPS land could not be sold. This land is a slack resource after the project reaches equilibrium and could be sold to increase the project surplus.

The best strategy that does not sell any land is significantly less effective than the optimal strategy. Without selling any land the best privatization strategy is to acquire additional land and build 900 new housing units in the first year. During the first seven years approximately 270 units can be renovated. In the eighth and ninth years the project debt peaks at $93 million as the last 1255 units are renovated. All new community facilities, except a guest lodge, are constructed in the first year.

The best strategy that does not sell land produces 24% less command utility than the optimal strategy and takes three times as long to revitalize the housing inventory. The average utility per unit of 7.17 reflects the final housing inventory of 63% renovated units

and only 37% newly constructed units. This strategy includes a housing shortage in the ninth year as the majority of existing housing assets are renovated. This shortage could probably be spread over a number of years but is unavoidable without additional housing units.

Not acquiring land when not selling land does not significantly change the total utility. We conclude that if the MBMH project does not sell land it cannot afford to acquire enough land to significantly improve the project's performance.

2. Maximum Debt Sensitivity Analysis

We also investigated the impact of limiting the MBMH project's maximum debt. The maximum debt represents the long term capital available to the MBMH project. We define the maximum debt is the largest debt ever carried from one year to the next during the MBMH project. It does not include the operating capital required during each year.

We assumed that the amount of capital available to the MBMH project will directly affect the total command utility and the time required to equilibrium. To test this hypothesis we optimized the MP model with a range of maximum debt levels from zero to $250 million. At the zero debt level the MBMH privatization is a "pay as you go" project with no long-term capital. A high maximum debt ($250 million) indicates that significant amounts of long-term capital are available. The optimal privatization strategy borrows $233 million and pays approximately $200 million in interest. Obligating almost 20% of the project's total revenue to interest on long-term debt represents a significant risk and may not be realistic. A maximum debt of $100 or $150 million, with the total interest charges equaling less than 10% of the total revenue, is a more reasonable debt load.

The optimization results indicate that the MBMH's optimal privatization strategy is to acquire all available land, build all new housing and sell the POM Annex land regardless of the maximum debt. This strategy always yields the highest command utility as well as a new housing inventory. Under adverse conditions such as a $50 million maximum debt and a commercial land value of $200,000 per acre this strategy replaces

over 60% of the housing inventory. (See Table 12.) (All optimization results discussed in this section are for a commercial land value of $500,000 per acre.)

Max. Debt ($M)	Total Utility	% Max. Utility	Avg. Utility	% New Units	Years to Revitalize Inventory	Community Facilities
$233	317,569	100 %	9.78	97.9 %	3	All new in year 1
$200	317,100	99.8 %	9.79	97.9 %	3	All new in year 2
$150	316,000	99.5 %	9.77	97.9 %	3	All new in year 2
$100	314,307	98.9 %	9.77	97.9 %	3	Guest lodge – year 2 All others – year 1
$50	310,743	97.8 %	9.77	97.9 %	6	Guest lodge incomplete All others – year 2
$0	304,684	95.9 %	9.67	97.9 %	9	Guest lodge – year 10 All others – year 2

Table 12. Maximum Debt Sensitivity Analysis Results (Researcher)

The maximum debt has little impact on the total command utility and the marginal utility of project debt decreases as the maximum debt increases. This is indicated by the decreasing slope in Figure 7. The first $50 million of debt yields an additional 1.9 % of maximum utility, while the fourth increment of $50 million of debt yields only 0.3% of maximum utility. The decreasing marginal utility is also evident in the average utility per housing unit. The increase in the average unit utility of the first $50 million of debt is 0.10 while it is only 0.02 for the last increment. (See Table 12.)

The maximum debt has a significant impact on the time required to revitalize the entire housing inventory. (See Figure 8.) Raising the maximum debt from zero to $100 million reduces the years required to revitalize the housing inventory from nine years to three years. However, increasing the debt over $100 million does not further reduce the number of years required to revitalize the housing inventory.

We conclude that the MBMH project should not incur more than $150 million debt because the marginal utility of additional debt is near zero above $150 million and the marginal time savings above $100 million is zero.

Figure 9 demonstrates that this conclusion holds for any land value between $100,000 and $700,000 per acre. The marginal utility of additional debt is the distance between the maximum debt lines.

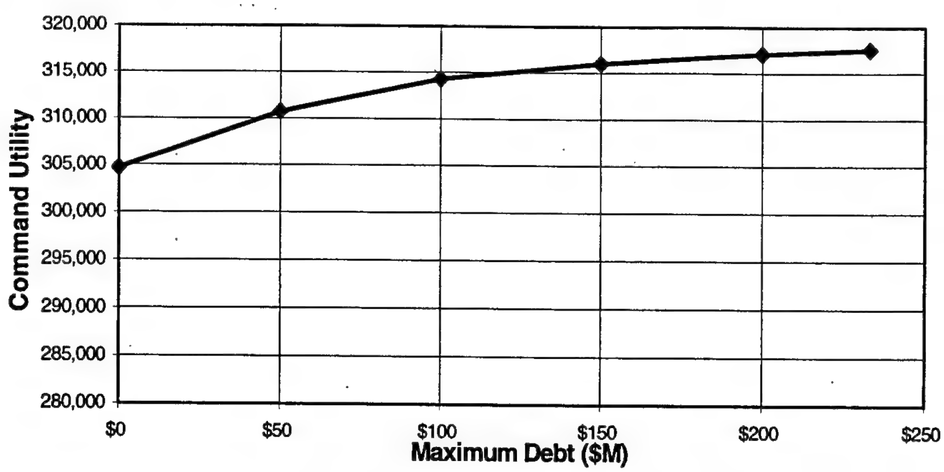

Figure 7. Total Command Utility vs. Maximum Debt (Researcher)

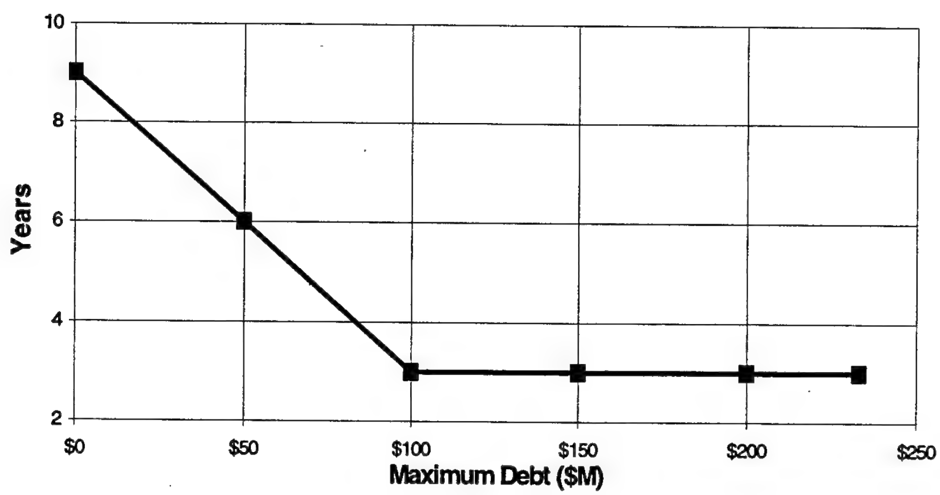

Figure 8. Years to Reach Equilibrium (Researcher)

The insignificant distance between the $150 million and $100 million lines indicate that the total utility is nearly unchanged by raising the maximum debt to $150 million.

However, the gap between the $0 and $50 million debt lines indicate a measurable performance increase. (No feasible solution was found for a zero project debt and $100,000 land value.)

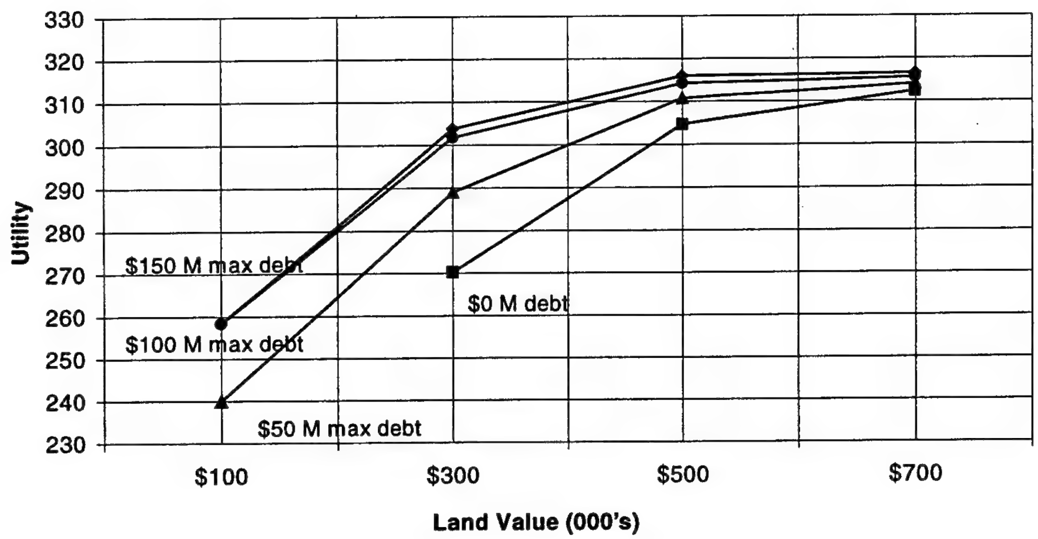

Figure 9. Maximum Debt Curves (Researcher)

The MP model results also indicate that the final project balance and the maximum debt are inversely related. (See Figure 10.) Although we did not use the ending financial balance as a performance metric (a surplus was not a primary objective of the MBMH project) we realize that decision-makers would consider the final balance in selecting a strategy. Therefore, we identified the maximum ending balance for each set of conditions (maximum debt and land value) by optimizing the model while maintaining the maximum utility.

3. Land Value Sensitivity Analysis

In the optimal privatization strategy the revenue from land sales is $191 million, accounting for 18.7 % of the MBMH project's total revenue. Therefore changes in the estimated value of the POM Annex land acre could significantly affect the MBMH project and change the optimal course of action. To estimate that impact we solved the MP model with land values ranging from $100,000 to $700,000 per acre. The cost of all

land available for acquisition was held constant at $60,000 per acre for Monterey County and $70,000 for Seaside. The maximum debt was unlimited.

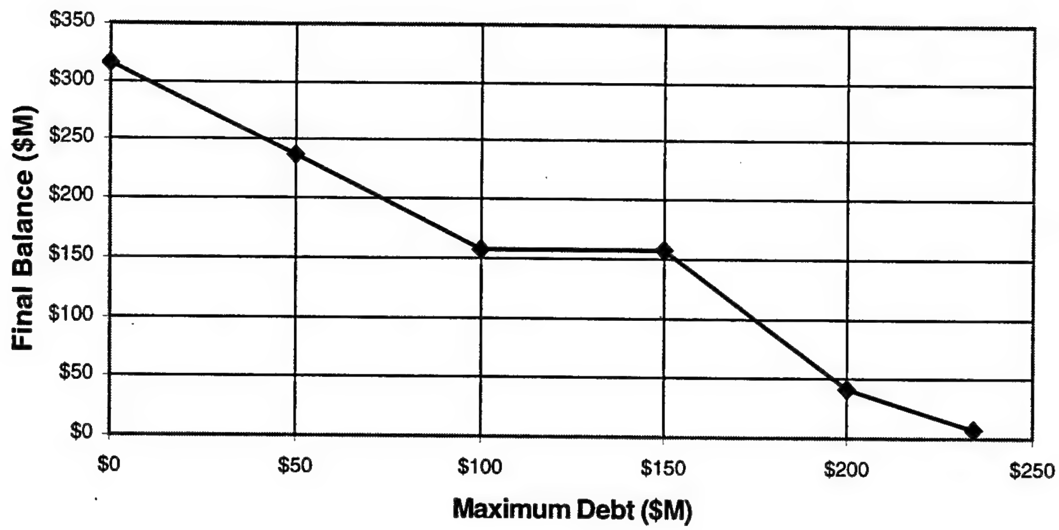

Figure 10. MBMH Final Balance vs. Maximum Debt (Researcher)

The results indicate that changes in the land value have a significant impact on the MBMH project. Specifically, the total command utility and average utility per housing unit are significantly reduced when land values are less than $300,000 per acre. However, land values above $500,000 per acre do not result in a significant increase in command utility. (See Table 13.)

Land Value	Total Utility	% Max. Utility	Avg. Utility / Unit	% New Units	Years to Revitalize Inventory	Community Facilities
$700 K	315,507	99.4 %	9.77	97.9 %	3	All new – year 2
$500 K	314,308	98.9 %	9.77	97.9 %	3	All new – year 2
$300 K	301,757	95.0 %	9.34	85.3 %	9	Guest lodge incomplete All others – year 2
$100 K	258,361	81.4 %	7.81	47.5 %	9	No guest lodge All others – year 1

Table 13. Results of Land Value Sensitivity Analysis (Researcher)

Commercial land value and command utility are positively correlated because higher land values enable the MBMH project to leverage larger amounts of capital. Additional capital allows the MBMH project to acquire more land, replace more of the existing housing inventory, construct more new community facilities, and reach equilibrium sooner. However, the marginal utility of increasing land values above $500,000 is very low.

G. MULTIPLE PERIOD MODEL CONCLUSIONS

The MBMH project must acquire additional land and housing during the first ten years to revitalize its housing inventory. Failure to do so will protract the revitalization process and lead to housing shortages. In all cases the optimal privatization strategy is to acquire additional land, build as much replacement housing as possible while renovating existing housing, and then sell all unused land. This strategy enables the MBMH project to meet the expanding housing requirements while constructing replacement housing units or renovating existing units.

Selling the POM Annex land enables the MBMH project to construct all new housing instead of renovating the existing housing and constructing some new housing. This strategy produces 32% more command utility than the best strategy that does not include selling land. (See Table 11, page 58.) This strategy results in an inventory of 30 year old housing units rather than an inventory of renovated 60 year old housing units. If the MBMH project does not sell land the optimal strategy is to acquire additional land and construct new housing units. This will enable it to renovate the existing inventory in ten years with a minimal housing shortage.

The optimization results indicate that the number of years required to revitalize the entire housing inventory and the total command utility are inversely related to the MBMH project's maximum debt. We conclude that the MBMH should borrow approximately $100 million, but no more than $150 million, to reduce the revitalization time and to increase the project's command utility. Borrowing up to $100 million

reduces the revitalization time to three years and yields a 5% increase in command utility. However, very little is gained by incurring more than $100 million in debt.

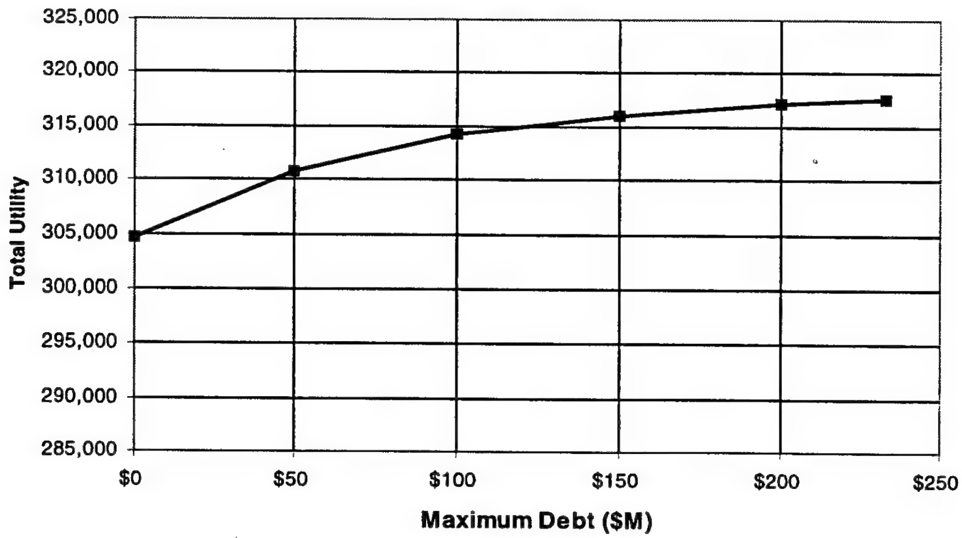

Figure 11. Total Command Utility vs. Maximum Debt Tradeoff Curve (Researcher)

The commercial value of the existing housing land has more impact on the MBMH project than the maximum debt, as revealed by the steeper slope of the land value lines than the maximum debt lines in Figure 12. This is because land sales provide almost 19% of the project's total revenue in the optimal strategy. Therefore, it is critical that the MBMH project planners have a good estimate of the POM Annex's commercial value.

We conclude that the commercial land value of POM Annex land must be at least $300,000 per acre to enable the MBMH project to meet its objectives. A lower value will restrict the project's ability to replace the existing housing and significantly reduce the total command utility. A higher value of $500,000 per acre will enable the project to quickly replace the entire housing inventory. (See Table 13.)

We conclude that the commercial land value is more important than the maximum debt. Tripling the maximum debt (from $50 million to $150 million) yields only 5,250 in

additional command utility. However, raising the land value from \$300,000 to \$500,000 yields approximately 12,600 in additional command utility. The difference between these marginal utilities is demonstrated in Figure 12. The steeper slopes of the land value lines indicate that the land value has a greater impact on command utility than the maximum debt.

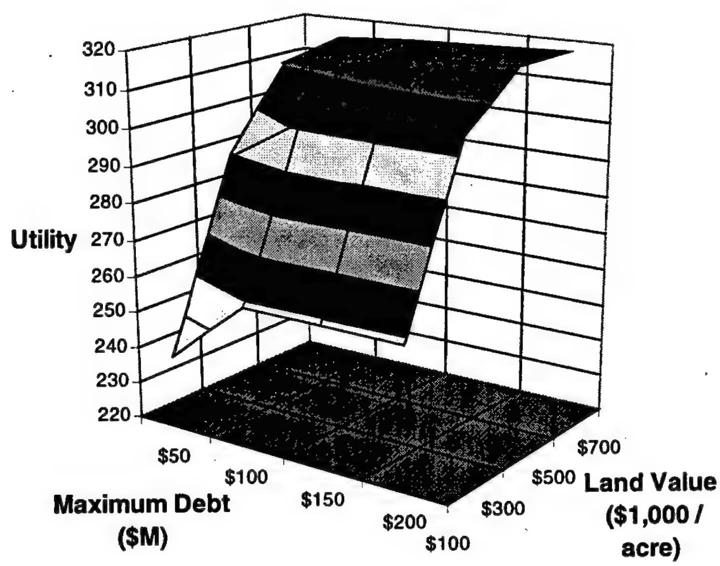

Figure 12. Command Utility vs. Maximum Debt and Land Value (Researcher)

V. CONCLUSIONS AND RECOMMENDATIONS

A. MBMH PROJECT

We make several recommendations to the MBMH decision-makers, based on the Steady State and Multiple Period model results. First, we recommend that the best privatization strategy for the MBMH project is to acquire additional land, build new housing, and then sell most of the POM Annex land when replacement housing is completed. The maximum debt should be $100 to $150 million. This strategy will allow the MBMH project to meet its housing requirement with all new housing units in three years. It also will have a project surplus of approximately $157 million at the end of 30 years, which can be used in future housing revitalizations. This strategy is described in detail in Appendix B.

The most critical decision that MBMH decision-makers face may be whether or not to sell the POM Annex property. Choosing to sell the POM Annex will allow the MBMH project to construct an entirely new inventory of family housing. The best privatization strategy without selling any land produces 24% less command utility and replaces only one-third of the existing housing inventory.

Second, we recommend the MBMH project aggressively investigate the opportunity to acquire additional land and sell existing housing land. Both of these actions are essential for the project to replace the entire inventory. This is a one-time opportunity as the authority to convey housing land to the public expires in 2001. In the optimal privatization strategy proceeds from land sales were approximately $191 million, increasing the project's financial assets by 23%. This additional funding enables the MBMH project to replace all of the existing inventory instead of just one-third. The funding also decreases the number of years required to complete the revitalization.

Third, we recommend that the MBMH project investigate alternative ways to reduce the housing shortage during revitalization. This shortage is created by the requirement to revitalize all of the existing housing and a growing NPS housing requirement. The MP model indicates that the shortage of housing and land during the first ten years is the limiting factor in the MBMH project. Relaxing this limit would allow the revitalization to be completed in less time and with fewer resources. One innovative way to do so may be to form partnerships with local municipalities to construct housing units off-post. Although such actions are unlikely to eliminate the housing shortage they may enable the MBMH project to avoid a housing shortage.

Several critical data should be reviewed by the MBMH decision-makers when considering our recommendations. The first is the future housing requirements. We expect some change in the housing requirements but any significant change will alter the optimal course of action. The general strategy of acquiring additional land, building new housing, and selling the POM Annex housing land will not change but the annual housing construction objectives, financial estimates, and years required to complete the revitalization could change dramatically.

The second critical datum to be reviewed is the commercial value of the POM Annex housing land. The MP model analysis indicates that an average commercial value of $300,000 per acre or less will significantly reduce the MBMH project's ability to quickly revitalize the housing inventory. However, average commercial land values in excess of $500,000 do not significantly improve the project's performance.

B. MODEL USAGE THROUGHOUT THE DOD

We developed the SS and MP models for use throughout the DoD with little user training. All of the data structures we used are common throughout the DoD; most of the population and housing asset data are in the standard installation housing reports. The only data not already captured at most installations are the local cost factors for

construction, demolition, renovation, annual maintenance, and utilities. Most installations can adapt the model for their use in less than two weeks.

The most important function of these models is to reduce a project's uncertainty. These models significantly reduce the uncertainty of housing privatization by identifying optimal revitalization strategies and related actions. In essence this makes the DoD a more "informed consumer" because it knows what level of housing the contractors should be able to provide. Otherwise the DoD relies on contractors to specify what is a reasonable return on DoD's investment.

Another important capability is to answer "what if" questions. Decision-makers frequently ask what impact a particular change has on the results. An example is "what if the interest rate on the debt increases by 1%?" Both models can quickly answer this type of question. These models will enable project planners to explore many options, as well as quantify the performance, cost and schedule tradeoffs. This will significantly reduce a project's uncertainty and risk.

The MP model can be used throughout the privatization process. Early in the process it can verify the feasibility of each military housing privatization project and provide detailed financial estimates to support congressional approval. This can identify the critical assumptions, data and decisions for each installation.

Later, the MP model can help develop detailed revitalization plans during the concept exploration and definition phase. These will be instrumental in developing the Request for Proposal (RFP). Developing a detailed project timeline will help the DoD clarify its objectives and priorities. Estimating the total and annual project costs will help decision-makers determine performance cost and schedule tradeoffs, as well as develop expected performance measures. It will also identify the critical assumptions and limitations, such as available funding or land, that may facilitate effective project management and risk reduction.

Finally, the MP model can help the DoD award privatization contracts. Given an installation's future housing requirements and local costs it can verify the feasibility of contractors' proposals. More importantly the model can estimate the best possible

performance of each contractor proposal. This will help the DoD compare dissimilar proposals.

The SS and MP models can help installations optimize their housing assignments even if they are not revitalizing their housing inventory. Because they consider many housing assignments not allowed under the current housing policies the models can recommend specific housing apportionment, cross-leveling, and redesignation actions.

APPENDIX A: MBMH MODEL INITIAL DATA

This appendix lists the data used in the MP model. This data is described in sections A and B of chapters three and four.

Water Usage Rates	(acre-feet / year)	
Existing Housing	As Is	Renovated
Senior Officer	0.3360	0.2856
Field Grade Officer, 4 bdrm	0.3360	0.2856
Field Grade Officer, 3 bdrm	0.2520	0.2142
Junior Officer, 4 bdrm	0.3640	0.3094
Junior Officer, 3 bdrm	0.2912	0.2476
Junior Officer, 2 bdrm	0.2184	0.1857
Senior Enlisted	0.3360	0.2856
NCO, 4 bdrm	0.3192	0.2714
NCO, 3 bdrm	0.2554	0.2171
NCO, 2 bdrm	0.1915	0.1628
Junior Enlisted, 4 bdrm	0.3192	0.2714
Junior Enlisted, 3 bdrm	0.2554	0.2171
Junior Enlisted, 2 bdrm	0.1915	0.1628

Water Usage Rates	(acre-feet / year)
New Housing	new
Senior Officer	0.2856
Single Fam. House, 4 bdrm	0.2856
Single Fam. House, 3 bdrm	0.2142
Duplex, 4 bdrm	0.3094
Duplex, 3 bdrm	0.2476
Duplex, 2 bdrm	0.1857
Townhouse, 4 bdrm	0.2714
Townhouse, 3 bdrm	0.2171
Townhouse, 2 bdrm	0.1628
Apartment, 4 bdrm	0.1904
Apartment, 3 bdrm	0.1428
Apartment, 2 bdrm	0.0952
BOQ, 3 bdrm	0.0560
BOQ, 2 bdrm	0.0560
BOQ, 1 bdrm	0.0560

Land Parcels	Acres	$000 / acre
La Mesa (NPS)	300	0
POM Annex		
Hayes West	47.5	500
Hayes East	15	500
Stilwell 1	50	500
Stilwell 2	95	500
Stilwell 3	44.5	500
Stilwell 4	9	500
Fitch 1	9	350
Fitch 2	201	300
Marshall 1	26.5	200
Marshall 2	121	200
PX back lot	24.5	100
Seaside	45.4	75
Monterey County #9	136	60
Monterey County #10	153	60

Land Usage Factors (acres / unit)

Existing Housing		New Housing	
Senior Officer	0.500	Senior Officer	0.500
Field Grade Officer, 4 bdrm	0.197	Single Fam. House, 4 bdrm	0.250
Field Grade Officer, 3 bdrm	0.198	Single Fam. House, 3 bdrm	0.250
Junior Officer, 4 bdrm	0.206	Duplex, 4 bdrm	0.167
Junior Officer, 3 bdrm	0.168	Duplex, 3 bdrm	0.167
Junior Officer, 2 bdrm	0.185	Duplex, 2 bdrm	0.167
Senior Enlisted	0.250	Townhouse, 4 bdrm	0.100
NCO, 4 bdrm	0.250	Townhouse, 3 bdrm	0.100
NCO, 3 bdrm	0.173	Townhouse, 2 bdrm	0.100
NCO, 2 bdrm	0.167	Apartment, 4 bdrm	0.071
Junior Enlisted, 4 bdrm	0.250	Apartment, 3 bdrm	0.071
Junior Enlisted, 3 bdrm	0.167	Apartment, 2 bdrm	0.071
Junior Enlisted, 2 bdrm	0.167	BOQ, 3 bdrm	0.071
		BOQ, 2 bdrm	0.071
		BOQ, 1 bdrm	0.071

Command Directed Service Levels

Maximum Service Level

# of dependents.	1	2	3	4
Senior Officer	90%	90%	90%	90%
Field Grade Officer	90%	90%	90%	90%
Company Grade Officer	95%	95%	95%	95%
Senior Enlisted	90%	90%	90%	90%
NCO	90%	90%	90%	90%
Junior Enlisted	95%	95%	95%	95%
Initial Entry Training	95%	95%	95%	95%

Minimum Service Level	1	2	3	4
Senior Officer	90%	90%	90%	90%
Field Grade Officer	90%	90%	90%	90%
Company Grade Officer	90%	90%	90%	90%
Senior Enlisted	90%	90%	90%	90%
NCO	90%	90%	90%	90%
Junior Enlisted	90%	90%	90%	90%
Initial Entry Training	90%	90%	90%	90%

Initial Housing Inventory

Non-Historic Units	Senior Enlisted	NCO, 4 bdrm	NCO, 3 bdrm	NCO, 2 bdrm	Junior Enlisted, 4 bdrm	Junior Enlisted, 3 bdrm	Junior Enlisted, 2 bdrm
La Mesa	0	0	0	0	0	0	0
Hayes West	0	3	94	32	0	0	0
Hayes East	0	0	0	0	7	16	22
Stilwell 1	0	0	0	0	4	83	63
Stilwell 2	0	0	0	0	4	255	91
Stilwell 3	3	0	0	0	0	0	0
Stilwell 4	0	0	0	0	0	0	0
Fitch 1	0	0	0	0	0	0	0
Fitch 2	0	0	0	0	0	0	0
Marshall 1	0	0	0	0	0	0	0
Marshall 2	0	90	264	0	0	0	0
POM	0	9	32	9	0	0	0
NPS / DLI ISSA	3	22	65	0	1	23	12
Historic Units							
POM	7	0	0	0	0	0	0
NPS	0	0	0	0	0	0	0
sum	13	124	455	41	16	377	188

Non-Historic Units	Senior Officer	Field Grade Officer, 4 bdrm	Field Grade Officer, 3 bdrm	Junior Officer, 4 bdrm	Junior Officer, 3 bdrm	Junior Officer, 2 bdrm	total in each parcel
La Mesa	0	52	214	30	239	54	589
Hayes We	0	0	0	0	0	0	129
Hayes Eas	0	0	0	0	0	0	45
Stilwell 1	0	0	0	0	0	0	150
Stilwell 2	0	0	0	0	0	0	350
Stilwell 3	2	4	17	4	51	28	109
Stilwell 4	2	0	0	0	0	0	2
Fitch 1	4	0	0	0	0	0	4
Fitch 2	0	16	70	30	240	90	446
Marshall	0	0	0	0	0	0	0
Marshall	0	0	0	0	0	0	354
POM	0	0	0	0	0	0	50
NPS / DL	1	18	78	29	248	100	600
Historic Units							
POM	13	6	2	1	3	5	37
NPS	14	0	0	0	0	0	14
sum	36	96	381	94	781	277	

Baseline Populations

DLI

Group # dependents	0	1	2	3	4
Senior Officer	0.0	3.0	2.0	2.0	1.0
Field Grade Officer	4.0	7.6	8.9	30.1	18.3
Company Grade Officer	36.3	24.5	36.2	47.2	29.7
Senior Enlisted	18.2	21.2	27.3	31.3	23.2
NCO	117.1	109.1	86.8	69.7	56.6
Junior Enlisted	723.2	148.4	63.1	25.1	7.3
Initial Entry Training	1567.2	226.3	90.4	34.5	5.8
				Total	3702.6

NPS

Group # dependents	0	1	2	3	4
Senior Officer	4.1	2.4	5.4	2.7	5.4
Field Grade Officer	54.2	89.7	97.1	150.7	69.9
Company Grade Officer	211.3	241.4	174	131.5	67.1
Senior Enlisted	1.4	4.1	2.7	16.2	8.1
NCO	31.1	25.7	23	35.1	25.7
Junior Enlisted	20.3	10.8	10.8	2.7	0
Initial Entry Training	0	0	0	0	0
				Total	1524.6

Independent Units

Group # dependents	0	1	2	3	4
Senior Officer	0	1	1	1	0
Field Grade Officer	2	4	5	6	5
Company Grade Officer	7	4	5	3	2
Senior Enlisted	5	8	7	10	13
NCO	14	26	9	15	9
Junior Enlisted	18	17	7	0	3
Initial Entry Training	0	0	0	0	0
				Total	207

Basic Housing Allowances ($000)

Officer Ranks	Annual BAH w/ dependents	Annual BAH w/o dependents	Enlisted Ranks	Annual BAH w/ dependents	Annual BAH w/o dependents
O-8	$17.0		E-9	$13.5	$10.3
O-7	$17.0		E-8	$12.2	$5.6
O-6	$16.7		E-7	$11.5	$8.0
O-5	$16.7	$13.8	E-6	$11.1	$7.5
O-4	$14.8	$12.9	E-5	$9.4	$6.6
O-3	$12.2	$10.3	E-4	$8.3	
O-2	$11.1	$8.7	E-3	$7.9	
O-1	$10.1	$7.5	E-2	$7.7	
WO-5	$14.7	$13.0	E-1	$7.7	
WO-4	$14.7	$13.0	IET-4	$8.3	
WO-3	$13.1	$10.6	IET-3	$7.9	
WO-2	$11.9	$9.3	IET-2	$7.7	
WO-1	$11.7	$8.9	IET-1	$7.7	

Community Facility Data	Acres required	cost to demolish ($000)	Utility / housing assignment	Acre-feet of water / year
Existing Community Facilities				
library	4	$ 400	0.1	6.72
Community Center	0	$ 500	0.05	33.60
Child Dev. Center	0	$ (5,000)	0.4	252.03
child/youth center	4	$ 400	0.2	126.02
fire station	8.5	$ 500	0.1	196.02
chapel	6	$ 500	0.1	6.72
service station	0			168.02
PX/COMM	0			268.83
New Community Facilities				
library	2	$ 800	1.5	10.08
Child Dev. Center	6.5	$ 5,000	4	252.03
putt putt	1	$ 50	1	44.81
Sports Center	2	$ 2,000	4	168.02
swimming pool	2	$ 3,000	3	168.02
guest lodge	6	$ 8,000	0.5	672.09
POM A playground	1	$ 100	2	0.00
Exercise Trail	0	$ 50	2	0.00
Fun Zone (Theater)	0	$ 100	1.5	179.22

Command Utility Functions

Standard Utility Function

	Size - 2	-1	0	+1	+2
Type +2	0%	-15%	-30%	-45%	-60%
+1	60%	50%	30%	10%	-10%
0	60%	85%	100%	90%	65%
-1	-20%	10%	30%	45%	60%
-2	-70%	-50%	-30%	-10%	0%

Un-revitalized Housing Units

	Size -2	-1	0	+1	+2
Type +2	0.00	-1.00	-2.00	-2.00	-3.00
+1	3.00	3.00	2.00	1.00	-1.00
0	3.00	4.00	5.00	5.00	3.00
-1	-1.00	1.00	2.00	2.00	3.00
-2	-4.00	-3.00	-2.00	-1.00	0.00

Revitalized Housing Units

	Size - 2	-1	0	+1	+2
Type +2	0.00	-1.00	-2.00	-3.00	-4.00
+1	4.00	4.00	2.00	1.00	-1.00
0	4.00	6.00	7.00	6.00	5.00
-1	-1.00	1.00	2.00	3.00	4.00
-2	-5.00	-4.00	-2.00	-1.00	0.00

New Housing Units

	Size - 2	-1	0	+1	+2
Type +2	0.00	-2.00	-3.00	-5.00	-6.00
+1	6.00	5.00	3.00	1.00	-1.00
0	6.00	9.00	10.00	9.00	7.00
-1	-2.00	1.00	3.00	5.00	6.00
-2	-7.00	-5.00	-3.00	-1.00	0.00

APPENDIX B: MBMH OPTIMAL STRATEGY

This appendix describes the optimal privatization strategy with a maximum debt of $250 million and land value of $500,000 per acre. Results are slightly different than those discussed in Chapter 5, based on a refined formula in the model.

<u>Communitiy Facility Actions</u>

Current Facilities	Year 1	Year 2
library	demolish 90%	demolish 10%
Community Center	retain	retain
Child Dev. Center	demolish 90%	demolish 10%
child/youth center	retain	retain
fire station	retain	retain
chapel	retain	retain

New Facilities	Year 1	Year 2
library	build 90%	build 10%
Child Dev. Center	build 90%	build 10%
putt putt	build 90%	build 10%
Sports Center	build 90%	build 10%
swimming pool	build 90%	build 10%
guest lodge	none	build 100%
POM A playground	build 90%	build 10%
Exercise Trail	build 90%	build 10%
Fun Zone (Theater)	build 90%	build 10%

Project Finances

Year	Annual Balance	Cumulative Balance
1	$ (150,000.00)	$ (150,000.00)
2	$ 16,642.53	$ (133,357.47)
3	$ 46,084.47	$ (87,273.01)
4	$ 4,884.68	$ (82,388.32)
5	$ 4,961.88	$ (77,426.44)
6	$ 4,567.61	$ (72,858.83)
7	$ 4,933.02	$ (67,925.81)
8	$ 5,327.66	$ (62,598.15)
9	$ 5,753.87	$ (56,844.28)
10	$ 6,213.79	$ (50,630.49)
11	$ 6,710.89	$ (43,919.60)
12	$ 7,247.77	$ (36,671.83)
13	$ 7,827.59	$ (28,844.24)
14	$ 8,453.79	$ (20,390.45)
15	$ 9,130.10	$ (11,260.35)
16	$ 9,860.51	$ (1,399.84)
17	$ 10,649.35	$ 9,249.50
18	$ 11,038.82	$ 20,288.32
19	$ 11,369.98	$ 31,658.31
20	$ 11,711.08	$ 43,369.39
21	$ 12,062.42	$ 55,431.80
22	$ 12,424.29	$ 67,856.09
23	$ 12,797.02	$ 80,653.11
24	$ 13,180.93	$ 93,834.04
25	$ 13,576.35	$ 107,410.39
26	$ 13,983.65	$ 121,394.04
27	$ 14,403.15	$ 135,797.19
28	$ 14,835.25	$ 150,632.44
29	$ 15,280.31	$ 165,912.75
30	$ 15,738.72	$ 181,651.46

Housing Assignments to:

Year	Un-renovated	Renovated	New
1	1726.3	2.8	536.5
2	229.2	21.3	2169.1
3	105.0	43.7	2279.8
4	0.0	35.1	2402.3
5	0.0	43.1	2403.3
6	2.2	48.8	2404.3
7	2.2	48.8	2404.3
8	2.2	48.8	2404.3
9	2.2	48.8	2404.3
10	0.0	51.0	2404.3
11	0.0	51.0	2404.3
12	0.0	51.0	2404.3
13	0.0	51.0	2404.3
14	0.0	51.0	2404.3
15	0.0	51.0	2404.3
16	0.0	51.0	2404.3
17	0.0	51.0	2404.3
18	0.0	51.0	2404.3
19	0.0	51.0	2404.3
20	0.0	51.0	2404.3
21	0.0	51.0	2404.3
22	0.0	51.0	2404.3
23	0.0	51.0	2404.3
24	0.0	51.0	2404.3
25	0.0	51.0	2404.3
26	0.0	51.0	2404.3
27	0.0	51.0	2404.3
28	0.0	51.0	2404.3
29	0.0	51.0	2404.3
30	0.0	51.0	2404.3

Land Actions

year	1	2	3	4	5	Total Fraction to Sell
Fraction to Sell						
La Mesa	0.0	0.0	0.0	0.0	0.0	0.0
Hayes West	1.0	0.0	0.0	0.0	0.0	1.0
Hayes East	1.0	0.0	0.0	0.0	0.0	1.0
Stilwell 1	0.3	0.0	0.7	0.0	0.0	1.0
Stilwell 2	0.0	1.0	0.0	0.0	0.0	1.0
Stilwell 3	1.0	0.0	0.0	0.0	0.0	1.0
Stilwell 4	1.0	0.0	0.0	0.0	0.0	1.0
Fitch 1	1.0	0.0	0.0	0.0	0.0	1.0
Fitch 2	0.3	0.0	0.7	0.0	0.0	1.0
Marshall 1	0.0	0.0	0.0	0.0	0.0	0.0
Marshall 2	0.0	0.0	0.4	0.0	0.0	0.4
PX back lot	0.0	0.0	0.0	0.7	0.3	1.0

Fraction to Buy						Total
SE-3	1	0	0	0	0	1
MOCO-9	1	0	0	0	0	1
MOCO-10	1	0	0	0	0	1

The following abbreviations are used to describe the housing actions:

Existing Housing		New Housing	
Senior Officer	SO4	Senior Officer	SO
Field Grade Officer, 4 bdrm	FG4	Single Fam. House, 4 bdrm	H4
Field Grade Officer, 3 bdrm	FG3	Single Fam. House, 3 bdrm	H3
Junior Officer, 4 bdrm	JO4	Duplex, 4 bdrm	D4
Junior Officer, 3 bdrm	JO3	Duplex, 3 bdrm	D3
Junior Officer, 2 bdrm	JO2	Duplex, 2 bdrm	D2
Senior Enlisted	SE	Townhouse, 4 bdrm	T4
NCO, 4 bdrm	NCO4	Townhouse, 3 bdrm	T3
NCO, 3 bdrm	NCO3	Townhouse, 2 bdrm	T2
NCO, 2 bdrm	NCO2	Apartment, 4 bdrm	A3
Junior Enlisted, 4 bdrm	JE4	Apartment, 3 bdrm	A2
Junior Enlisted, 3 bdrm	JE3	Apartment, 2 bdrm	A1
Junior Enlisted, 2 bdrm	JE2	BOQ, 3 bdrm	B3
		BOQ, 2 bdrm	B2
		BOQ, 1 bdrm	B1

Year 1	SO4	FG4	FG3	JO4	JO3	JO2	SE	NCO4	NCO3	NCO2	JE4	JE3	JE2		
Reno. Non-Hist.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Demo. Non-Hist.	0.0	0.0	0.0	23.5	0.0	0.0	0.0	63.6	18.4	0.0	0.0	0.0	0.0		
Reno. Historic	8.4	0.0	0.0	0.0	0.0	0.0	0.0								
	SO	H4	H3	D4	D3	D2	T4	T3	T2	A3	A2	A1	B3	B2	B1
Build New	0.0	254.0	71.4	267.4	232.8	258.2	190.4	122.4	144.9	59.2	545.3	0.0	0.0	0.0	0.0

total renovated 8.4 total demolished 105.5 total built 2146.0

Year 2	SO4	FG4	FG3	JO4	JO3	JO2	SE	NCO4	NCO3	NCO2	JE4	JE3	JE2		
Reno. Non-Hist.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Demo. Non-Hist.	0.0	0.0	109.0	6.5	0.0	54.0	0.0	0.0	92.4	0.0	0.0	0.0	0.0		
Reno. Historic	14.8	6.0	2.0	1.0	3.0	5.0	7.0								
	SO	H4	H3	D4	D3	D2	T4	T3	T2	A3	A2	A1	B3	B2	B1
Build New	0.0	86.9	3.2	0.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

total renovated 38.8 total demolished 261.9 total built 92.3

Year 3	SO4	FG4	FG3	JO4	JO3	JO2	SE	NCO4	NCO3	NCO2	JE4	JE3	JE2		
Reno. Non-Hist.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Demo. Non-Hist.	0.0	52.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Reno. Historic	3.8	0.0	0.0	0.0	0.0	0.0	0.0								
	SO	H4	H3	D4	D3	D2	T4	T3	T2	A3	A2	A1	B3	B2	B1
Build New	0.0	1.1	153.8	4.7	0.0	2.3	1.8	0.7	0.7	0.1	0.7	0.0	0.0	0.0	0.0

total renovated 3.8 total demolished 52.0 total built 165.9

Year 4	SO4	FG4	FG3	JO4	JO3	JO2	SE	NCO4	NCO3	NCO2	JE4	JE3	JE2		
Reno. Non-Hist.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Demo. Non-Hist.	0.0	0.0	26.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Reno. Historic	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
	SO	H4	H3	D4	D3	D2	T4	T3	T2	A3	A2	A1	B3	B2	B2
Build New	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

total renovated 0.0 total demolished 26.6 total built 1.0

Total Actions	SO4	FG4	FG3	JO4	JO3	JO2	SE	NCO4	NCO3	NCO2	JE4	JE3	JE2		
Reno. Non-Hist.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Demo. Non-Hist.	0.0	52.0	135.5	30.0	0.0	54.0	0.0	63.6	110.8	0.0	0.0	0.0	0.0		
Reno. Historic	27.0	6.0	2.0	1.0	3.0	5.0	7.0								
	SO	H4	H3	D4	D3	D2	T4	T3	T2	A3	A2	A1	B3	B2	B2
Build New	0.0	342.0	228.5	273.0	234.1	260.6	192.2	123.0	145.6	59.3	545.9	0.0	0.0	0.0	1.0

total renovated 51.0 total demolished 445.9 total built 2405.3

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